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EFFECT OF ATROPINE AND ESTROGENS ON INTRAOCULAR UTERINE TRANSPLANTS IN THE RABBIT

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From the Department of Embryology, Carnegie Institution of Washington, Baltimore 5, Maryland

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The transplantation of organs or parts of organs to the anterior chamber of the eye provides unique opportunities for the study of the morphologic manifestation of physiological responses, since the transparency of the cornea allows observation without anesthesia of the structures which implant in the anterior chamber. The uterus undergoes alterations under physiological conditions which are particularly suitable for such observation. The endometrium manifests characteristic changes in color and size in response to hormone deprivation and estrogen and progesterone stimulation, while contractions of the myometrium produce discernible motion.

In the course of a study of the mode of action of prostigmin as an emmenagogue it appeared desirable to reinvestigate the supposed cholinergic mechanism of estrogen action on the endometrium of the rabbit, taking advantage of the physiologic conditions available with intraocular transplants. The results of this investigation cast serious doubt on the hitherto accepted conclusion that estrogens produce vasodilatation and stasis of the endometrial vessels by local production of acetylcholine.

MATERIALS AND METHODS

The thirty-one rabbits employed in these experiments were standard laboratory animals of no particular strain, purchased from a local dealer and subsequently kept in individual cages on a laboratory diet. They were all in good health with the exception of a few animals which were sacrificed because of chronic suppurative otitis media secondary to tick infestation of the external ear. No animal was

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mated during the experimental period and none became pseudopregnant except as noted. Only autotransplants were made.

Operations were performed under anesthesia with intravenous barbiturates or ether by cone, neither of which was entirely satisfactory. The abdomen was opened and the ovaries inspected. A small segment of uterus, usually from the left side, was then excised with scissors. No effort at hemostasis was made, simple closure of the abdominal wound being found adequate. In the earlier experiments this segment was placed on a gauze sponge and opened lengthwise. It was then spread out on its serosal surface and with fine curved scissors attempts were made to remove small segments of endometrium from the myometrium. In many cases the wall of the uterus thus spread out was so thin that most fragments included the entire thickness of the wall. By trial and error a few partial-thickness slices could be obtained Later in the series, at the suggestion of Dr. J. Eldredge Markee, the opened uteri were laid on the index finger and then cut with scissors, but this technique did not increase the rate of successful grafting. In an attempt to solve this problem, several animals were injected with human pregnancy urine and operated upon on the 12th day, at which time a thick uterine wall was present. It was then simple to excise small fragments of endometrium and transplant them, but as the pseudopregnancy receded these grafts gradually vanished, and none reappeared during subsequent hormonal stimulation. Considerable attention was paid to this technical problem of obtaining endometrium without myometrium for grafting because in the vast majority of grafts the physiologic activity was dominated by myometrial contractions, rendering the grafts unsuitable for the particular purposes of these experiments. The problem was not solved, and the successful endometrial grafts were obtained by apparently fortuitous circumstances which could not be reproduced. Every successful graft at one time or another manifested myometrial activity.

The eyes were prepared for operation by instillation of saturated boric acid solution. It was found that ether, which lowered the intraocular tension, rendered the operation more difficult, while the intravenous barbiturates did not. Preoperative atropine administration also caused technical difficulties. In the majority of cases the

right eye only was used, as described below, and two grafts were placed, but in some experiments both eyes were employed. The upper lid and nictitating membrane were retracted by an assistant. The cornea was incised with an iridectomy knife at a position corresponding to about 2 o'clock on a dial and about 2 mm. from the corneoscleral margin, the blade being held parallel with the margin and inserted with a rapid stabbing motion. Occasionally the underlying iris was lacerated by the knife blade, but serious hemorrhage resulted only when the incision had been made too close to the corneoscleral margin. Such hemorrhage usually resulted in failure of the grafts. The corneal incision was then extended slightly inferiorly with fine scissors. The fragment of uterus was grasped with a fine toothed forceps and inserted into the anterior chamber. Because of the small size of the grafts, no effort could be made to orient the uterine tissue layers within the anterior chamber. Once inside the chamber, the uterine fragments were manipulated into position at 10 and 12 o'clock in the corneoiridial angle by use of counter-pressure against the cornea with the rounded end of a scalpel handle or forceps. The cornea was not sutured.

Postoperatively, considerable hemorrhage was observed in only a few animals, and in these the grafts were usually not successful, due to scarring of the graft and corneal opacity. Most grafts were hemorrhagic for the first 5 to 7 days Several animals suffered infections of the cornea. A few of these were treated with instillations of sulfathiazole ointment in the conjunctival space, with marked resolution of the superficial keratitis and conjunctivitis, but most of these animals had a residual haziness of the cornea. It was noted that however damaged a graft might look one or two weeks after operation, after one month it might eventuate as a successful take with little or no corneal reaction The cornea healed promptly in all but the few cases in which pieces of graft herniated into the corneal defect. In these there was marked infection. Once a successful take was established the animal required no further special care and, although the operated eyes appeared to have defective vision this did not seriously alter the animals' general or mating behavior. The conclusion that vision was defective in the operated eyes is based on the observations that these animals were invariably found in their cages sitting with

the unoperated eye toward the room, and that they usually had suffered subluxation of the lens.

For observation, the animals were strapped to boards in the supine position and covered with a towel to conserve body heat. The head was held in position and the eyelids retracted by the observer's left hand. A large binocular dissecting microscope to which a lamp with a condensing lens had been attached was then swung into place over the eye and observations were begun. Continuous records were kept of all experiments with a watch and stop-watch, so that the time of onset and duration of any changes could be noted. Injections were given in the ear veins, which were usually prepared in advance by shaving the ear. These caused no fright response from the animals unless a dull needle was employed or an extravasation occurred. The majority of animals quieted down after the first few minutes of observations and remained quiet and unresisting for the course of the experiments, some of which lasted as long as 150 minutes. On occasion violent struggling precluded observation for brief periods of time, but if this became too marked the experiment was discontinued.

In the course of this study, all injections were made by the intravenous route. Atropine sulphate was employed in 1% aqueous solution. Amniotin in corn oil solution[2] was given in amounts ranging from 150 to 500 i.u. 0.01 mgm. of stilbestrol, estimated to be equivalent to 250 i.u. of estrone, was given in corn oil solution. 220 i.u. of sodium estrone[3] was given in aqueous solution. All injections were administered by an assistant, from a tuberculin syringe.

Preparations for microscopic study were made by excising the eyes immediately after the animal was sacrificed and immersing them in Bouin's fluid. With a 26-gage needle Bouin's fluid was mixed with the vitreous humor by injecting small amounts of the fixative and withdrawing part of the vitreous. This was repeated until a high concentration of Bouin's fluid was obtained, without at any time collapsing the globe. The eye was then turned over and Bouin's fluid similarly

[2] The Amniotin employed in this study was generously provided by E. R. Squibb and Sons Inc.

[3] The estrone (Menformon) employed in this study was generously provided by Roche Organon Inc. as an aqueous solution of the sodium salt in a concentration of 1400 i.u. per cc.

injected into the anterior chamber. After 24 hours a large window was cut in the posterior hemisphere of the globe. This technique insures optimal fixation and maintenance of anatomical relationships. The blocks were imbedded in celloidin and paraffin for several weeks so as to minimize fragmenting of the cornea and then serially sectioned at 15 mu.

APPEARANCE OF GRAFTS

The particular shape assumed by the graft is not in any obvious way related to the shape of the tissue fragment implanted in the anterior chamber. Grafts implant in the iris or on the cornea or both. When implantation on the iris has occurred, contraction of the iris produces slight changes in the grafts which do not interfere with observations. In all cases many blood vessels descend over the surface of the sclera toward the corneoscleral border adjacent to the graft, where the majority of them apparently penetrate the globe to supply the graft. Some smaller branches of capillary size extend in a network over the surface of the cornea in the region of the graft and, if this is near the corneal incision, to the corneal scar as well. Vessels are occasionally observed coursing in the iris toward the graft, but the bulk of the blood supply of the grafts appears to come through the scleral vessels rather than through the blood supply of the iris.

The grafts themselves are made up of delicate looking tissue of an orange to pink color, whose free borders are clean and sharply defined. Many of the vessels can be clearly seen either on the surface or in the substance of the graft. In some grafts arterioles and venules are present but most vessels are of capillary size. In one large graft it is possible to observe the mouths of endometrial glands on the inferior free border. Fragments of uveal pigment are imbedded in some grafts and this pigment is often heaped up at the margins of the iridial attachment. Some of these features can be seen in Figure 1.

As can be seen in Figure 2, the endometrium maintains its histological integrity in the anterior chamber. The transition from surface epithelium of the endometrium to iridial or corneal epithelium is a gradual one and the stroma of the iris and endometrium tend to blend together at the margins of the grafts. Endometrial cysts of microscopic size are frequent. The myometrium present in the graft is

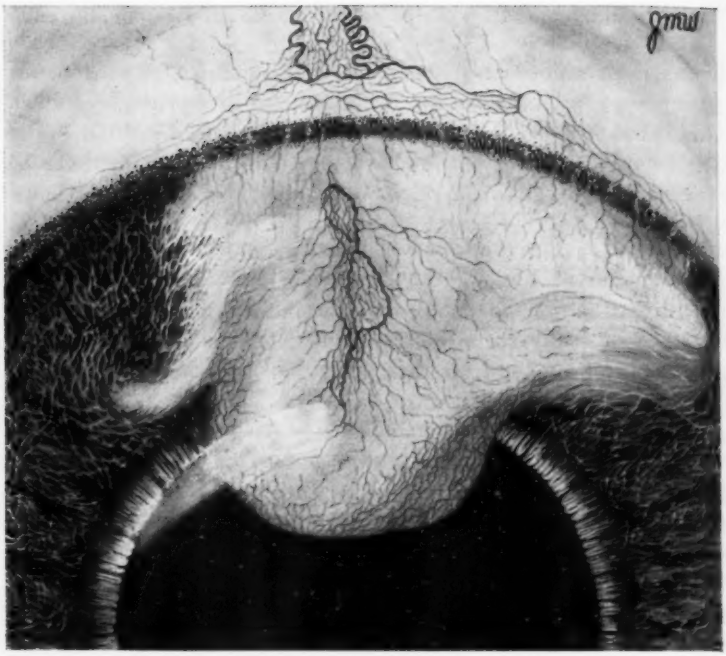

FIG. 1. DRAWING SHOWING PORTION OF A RABBIT'S EYE WITH A UTERINE GRAFT IMPLANTED IN THE ANTERIOR CHAMBER

The cornea is unaltered except for the whitish area in the cornea at the extreme left. This is the healed scar of the incision made for the insertion of the tissues for grafting. The largest visible portion of the graft, which is orange in color, is applied to the internal surface of the cornea. The small rose-red area at the lower right side of the graft is the only visible surface free in the anterior chamber. At the right and left sides of the graft there are areas of fibrous scarring, yellow in color, which form part of its attachment to the iris. These scars distort the iris.

The large vessels which run toward the graft in the superficial layers of the sclera give off numerous small lateral channels which run along the corneoscleral border. These in turn give rise to smaller branches which run into the cornea over the region of the graft.

In the center of the graft lie its main vessels, an anastomosing group which forms a rough figure-of-eight. These vessels travel in the superficial layers of the graft almost immediately beneath the cornea. They give rise to many smaller branches. Many of the capillaries visible in the graft do not appear to arise from this main group. Rhythmical vasoconstriction can be observed in the vessels of the graft itself in the absence of any alterations in the vessels of the sclera, cornea or iris.

always placed at the main site of attachment and blends into the substance of the iris by fibrous union. Myometrial bundles are readily identifiable and readily distinguished from the iridial musculature by their position within the graft. The major blood vessels supplying the graft course through these bundles of myometrial fibers, as demonstrated in Figure 3. In some cases the bulk of the graft is found behind the iris where it could not have been observed in the intact animal.

ACTIVITY OF THE GRAFTS

In the process of observation for brief periods of time, only muscular and vascular activity can be observed. The growth processes of endometrium are not discernible.

Muscular activity can be identified by the occurrence of visible contractions. Not infrequently these are of very slight amplitude and can be seen only when the graft is viewed from an advantageous angle. As has been noted, in most cases the vascular supply of the graft enters through the muscle bundles and contractions are followed by paling of the remainder of the graft. This paling proceeds from the area of attachment of the myometrial fibers to the iris to the rest of the graft, making it appear as if the arterial supply were completely occluded but the venous drainage at least partially free so that all blood rapidly empties out of the graft. These muscle contractions last from 20 to 45 seconds and the paling of the graft a corresponding length of time. Once the behavior of a particular graft becomes familiar to the observer, it is possible to identify contractions without observing the movement which they produce.

Vascular activity also occurs spontaneously in mature animals with intact ovaries, in the absence of heat or mating. Every 45 to 120 seconds the vessels of the graft fade out of sight for periods of 5 to 20 seconds. The fading is not accompanied by any visible muscular contraction. This paling does not appear to be initiated in any particular area, nor does it affect all the capillaries in the graft completely, so that there is always some residual orange-pink ground color remaining in the graft. During the phase without vasoconstriction, there is no fluctuation in the caliber or number of patent vessels, so that in fact there is no blush. The rhythmical vasoconstrictions continue at a rate of about 30 to 60 per hour for as long as observation is maintained.

FIG. 2

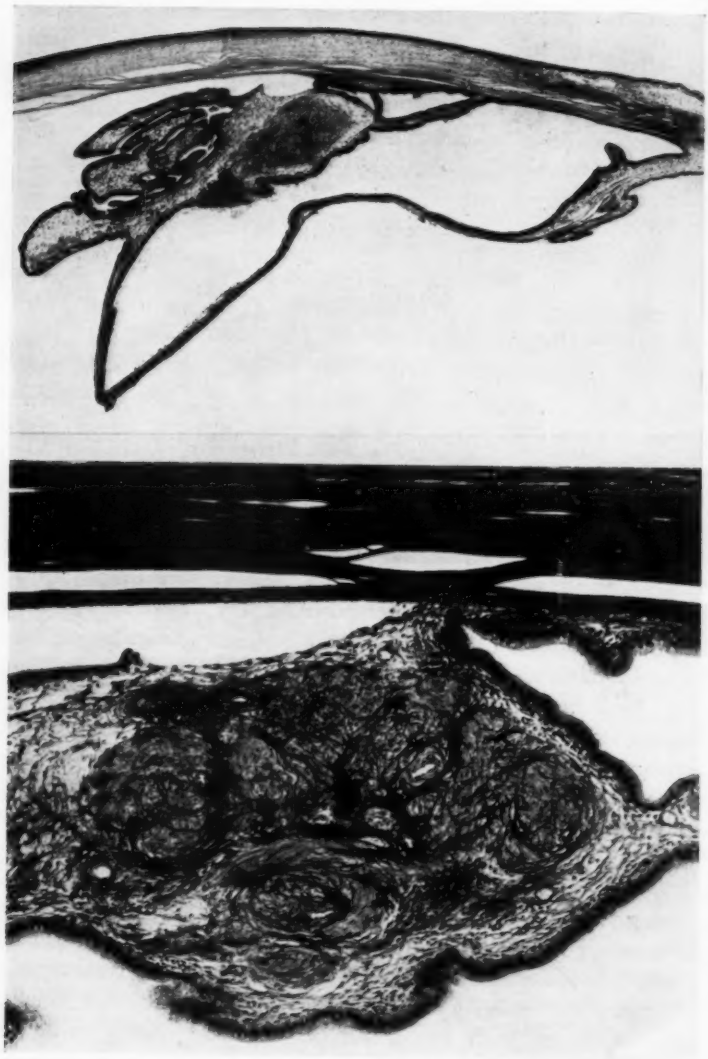

FIG. 3

The phenomenon involves only the intrinsic vessels of the graft and does not affect iridial or scleral vessels related to the graft.

In response to fright, the vessels of the graft undergo intense vasoconstriction which results in a bloodless deathly white appearance in the graft. This persists for 10 to 25 seconds and also affects, to a lesser degree, the vessels at the corneoscleral margins. It is usually accompanied by a muscular contraction whose characteristics differ in no way from those described for the spontaneously occurring contractions except that the fright contraction is occasionally more intense or more prolonged. There is no rhythmical pattern to the vasoconstrictions of fright. On the basis of these characteristics they can readily be distinguished from the rhythmical vasoconstrictions.

In certain grafts, both muscular contractions and rhythmical vasoconstrictions are present. Often the myometrial phenomena occur at 5 minute intervals and the more frequently occurring vasoconstrictions can be identified. Of course, if a muscle contraction immediately

FIG. 2. CROSS SECTION OF A UTERINE GRAFT IN THE ANTERIOR CHAMBER OF ANOTHER RABBIT'S EYE (R5-200), STAINED WITH HEMATOXYLIN, EOSIN AND PHLOXINE AND ENLARGED 20 TIMES

The margin of the sclera is at the right. The cornea runs across the remainder of the upper portion of the photograph. Two corneoscleral vessels can be seen just under the bulbar conjunctiva at the right. The low cuboidal epithelium of the iris covers the entire posterior border of the iris and the graft and blends into the darker staining ciliated columnar epithelium of the uterine graft at the left. This uterine epithelium forms typical endometrial glands supported by endometrial stroma in the portion of the graft to the left. It also forms one large and two small cystic spaces. Just to the left of the center of the photograph there is a large group of myometrial bundles through which the main arterial channels of the graft pass. These may be seen more clearly in Figure 3.

FIG. 3. VAN GIESON STAIN OF A SECTION (R5-204) ADJACENT TO THE ONE IN FIGURE 2, ENLARGED 100 TIMES

The deeply staining fibers of the cornea run across the top of the photograph. The uterine epithelium which lines the cystic areas is columnar and in some places its ciliated border can be made out. In the center of the photograph the brown staining smooth muscle fibers of the myometrium form bundles which encircle at least three small arteries. Several small veins are present at the periphery of the group of myometrial bundles, encased in fibrous tissue. These vessels form the vasculature of the uterine graft.

precedes vasoconstriction there is no way, with present techniques, of being certain that the latter has occurred. For that reason, in keeping the protocols of these experiments, all paling of the graft which was preceded by visible myometrial contraction was regarded as a muscle response only.

A few grafts exhibit vasoconstrictions at one time and myometrial responses at another. In addition, when two grafts are present in the same eye, one may exhibit muscle contractions and the other vasoconstrictions. It is therefore necessary to observe each graft carefully during a control period to determine its physiologic status before administering any substance.

RESULTS

Effect of Atropine. The effect of atropine is entirely dependent upon the type of physiologic activity present in the graft at the time of administration. In the doses employed, atropine acts to slow or halt endometrial vasoconstrictions, whereas it has no predictable effect on myometrial contractions. As can be noted in Table I, there is no direct correlation between dose and the degree or duration of effect of atropine on vasoconstrictions, except that the larger doses appear to be slightly more effective. The greatest and least percentage changes were obtained with the same dose. The effect in general begins to wear off within ten minutes of administration of the drug, but complete cessation of vascular activity for periods as long as 45 minutes is observed.

During the periods when vasoconstrictions are halted, the vessels have an engorged appearance but additional vascular channels do not appear to open, and it may well be that the appearance of engorgement is simply due to the striking contrast of inactivity with the periodic constrictions which are observed before atropine. The full effect of estrogens is strikingly different.

The blood vessels of grafts which do not manifest either vascular or myometrial activity are not affected by atropine.

The effect of atropine on myometrial contractions in intraocular transplants is quite unpredictable. As may be seen in Table II, it may produce decrease or increase in the rate of contractions. These effects are not dependent upon the size of the dose. Except for changes

in the rate of contraction, the appearance of the grafts is in no wise altered, and the vascular phenomena described in grafts manifesting rhythmical vasoconstriction are not observed.

Effect of Estrogens. There are no significant differences among the estrogens employed in their effects on vasoconstrictions and contractions. Shortly after the administration of the hormone, the vasoconstrictions begin to decrease in frequency until at the end of one hour

TABLE I

Effect of Atropine on Endometrial Vasoconstrictions in Intraocular Transplants

DOSE OF ATROPINE	NO. OF RABBIT	DATE	CONTROL—15 MIN. PERIODS*	RESULT—CONSTRICTIONS PER HOUR*	
			Constrictions per hour	First 15 mins.	Second 15 mins.
mgm.					
0.6	41	Aug. 13	32	8	8
	41	Aug. 14	36	12	12
	41	Aug. 19	32	8	8
	41	Aug. 20	40	4	16
2.0	41	Aug. 21	44	20	
	41	Aug. 23	56	0	12
	39	Sep. 10	48	4	28
	39	Oct. 18	56	16	44
	39	Oct. 24	60	8	28
4.0–6.0	41	Sep. 13	48	4	20
	5	Oct. 21	24	0	0
	5	Oct. 15	36	0	
	39	Sep. 19	60	0	
	39	Oct. 9	72	20	52
	39	Oct. 29	52	24	

* In each experiment the data given represent consecutive periods during continuous observation.

vascular activity has virtually ceased. With amniotin, this effect begins to wear off after one and one-half hours, but with sodium estrone and stilbestrol it persists for as long as three hours. This effect is presented in graphic form in Chart IA. Coincidently with this slowing of rhythmical vasoconstrictions there occurs a gradual dilatation of the vessels and the appearance of new channels, so that at the peak of hormone effect the graft has an intense rose-red color which provides a

striking contrast to the unaltered appearance of the vessels of the adjacent corneoscleral border. This engorgement is observed, in much less striking form, in grafts which have not manifested endometrial vasoconstrictions during the control period. Estrogens do not appear to influence the rate, duration or intensity of myometrial contractions during the course of these acute experiments.

TABLE II

Effect of Atropine on Myometrial Contractions in Intraocular Transplants

DOSE OF ATROPINE	NO. OF RABBIT	DATE	CONTROL—15 MIN. PERIOD*	RESULT—CONTRACTIONS PER HOUR*	
			Contractions per hour	First 15 mins.	Second 15 mins.
mgm.					
0.6	14	Aug. 14	36	28	
	14	Aug. 20	28	28	
	31	Oct. 31	60	32	40
2.0	14	Aug. 26	40	36	
	31	Oct. 18	36	16	24
	39	Oct. 24	8	16	8
	41	Oct. 22	24	0	4
	5	Oct. 30	40	28	32
4.0	5	Oct. 21	16	0	4
	12	Oct. 21	16	12	20
	14	Aug. 28	32	44	24
	31	Oct. 24	32	24	36
	35	Oct. 24	44	44	
	41	Oct. 30	40	12	28
6.0	14	Oct. 4	24	28	24
	41	Oct. 2	20	16	
	12	Oct. 30	24	16	12
	35	Oct. 31	40	32	44

* In each experiment the data given represent consecutive periods during continuous observation.

Influence of Atropine on the Effect of Estrogens. The administration of large (4 to 6 mgm.) doses of atropine prior to, simulatenously with or subsequently to the administration of estrogens in no way alters the effect of the latter on endometrial vasoconstrictions. This relationship may be seen in Chart IB, which illustrates three experiments in which atropine produces its expected effect of slowing vasoconstrictions

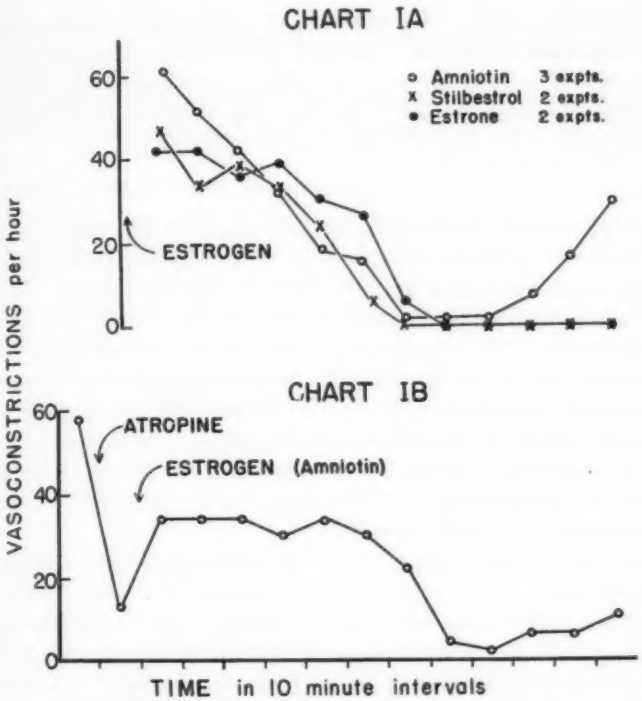

CHART I. Chart IA demonstrates the delayed effect of three estrogens in reducing the rate of endometrial vasoconstrictions. Chart IB demonstrates the immediate reduction in the rate of vasoconstrictions due to atropine. Administration of estrogens intravenously ten minutes after atropine then produces the same delayed effect seen in IA, at about the same time. Beginning recovery from the atropine can be observed in the second ten minute period in IB. Administration of atropine alone does not produce the delayed effect demonstrated in IB.

The dose of estrogens employed in this group of experiments varies from 150 to 500 i.u. of estrone. The majority are about 250 i.u. (0.01 mgm. of stilbestrol). The dose of atropine is 4 to 6 mgm. The arrows indicate the time of intravenous administration of the drugs. The abscissa is divided into consecutive 10 minute periods. Each point plotted represents the average number of vasoconstrictions observed in each time period, expressed as vasoconstrictions per hour, as indicated on the ordinates.

and, while this is at its maximum, amniotin is given. As the atropine effect is waning, estrogen effect is waxing, thereby producing a plateau

for a brief period. The cessation of rhythmical activity and the vasodilatation which mark estrogen effect appear at about the time they would be expected to do so without atropine effect. The continuing physiologic action of atropine may be noted by the mydriasis which persists for 18 to 48 hours in these animals.

DISCUSSION

In the course of this investigation, many of the observations of Markee (3, 4, 5) and Neumann (6, 7) on the physiology of intraocular endometrial transplants in the rabbit have been confirmed.[4] Perhaps the most frequently discussed of these is the "blush and blanch" phenomenon. This rhythmical paling of the endometrium in the eye grafts also occurs in primates, and since menstruation is preceded by a period of ischemia a relationship between the "blush and blanch" and the menstrual process has been suggested. "Blush and blanch" is an unfortunate epithet for the phenomenon because there is no phase of vasodilatation. On the other hand, rhythmical paling describes what is actually observed.

The entire blood supply of the endometrium passes through the myometrium. It is obvious that contractions of uterine muscle will therefore reduce endometrial blood supply when the pressure they exert exceeds the diastolic pressure within the myometrial arteries. Nevertheless, in the present study rhythmical paling of endometrium has been observed in the absence of visible myometrial contraction. It is possible that this paling is due to changes in myometrial tonus without perceptible contraction but the remarkable cessation of activity in the endometrium in response to atropine makes this unlikely. The phenomenon appears to be intrinsic in the endometrial vessels and has therefore been designated as rhythmical vasoconstriction. In the intact uterus, rhythmical paling is due to rhythmical myometrial contraction and to rhythmical vasoconstriction. The concept of endometrial activity as separate from myometrial activity may be of value in the experimental analysis of events, as it has been

[4] See also Jacobsen, E. M.: Response of intraocular endometrial implants to estrogens in the female rabbit. Endocrinology, **34**: 376–388 (1944), for a discussion of the effects of estrogens over longer periods of time than those considered here.

here, but caution must be exercised in applying it to uterine phenomena in the living animal.

The present observations of the unpredictable effect of atropine on myometrial behavior confirm previous studies of uterine motility in the rabbit. They also indicate that intraocular transplantation makes possible the observation of muscle behavior without the imposition of work upon the muscle. In conventional physiological experiments, muscle exerts force against a load in the process of making records. In the anterior chamber no such load exists, yet accurate qualitative observation is simple. In this laboratory, the oxytocic effects of certain antihistaminic substances were initially noted in intraocular transplants and later confirmed by conventional techniques (2).

The failure of atropine to inhibit the action of estrogen upon endometrial vasoconstrictions appears to negate the so-called cholinergic concept of estrogenic effect on the endometrium. Pompen in 1933 (8), observing the intact rabbit uterus through a window in the abdominal wall, noted that the administration of small amounts of estrogen, in the same dose range as those used in the present study, caused vascular stasis and dilatation. He further noted that this effect was prevented by the prior administration of atropine intravenously. Reynolds, in a series of publications (9, 10, 11, 12), analyzed the changes in the acetylcholine content of the castrate rabbit uterus following the administration of small amounts of various estrogens, and found that there was a marked rise in acetylcholine after every estrogen except stilbestrol. Emmens' (1) subsequent inability to confirm this may have been due to differences in technique of determining acetylcholine. Soskin, Wachtel and Hechter (13) later assumed, on the basis of Reynolds' findings for the whole uterus, that estrogen effect on endometrium was due to acetylcholine. Pompen, however, was not observing endometrium, nor did Reynolds assay the layers of the uterus separately. In the present study it has been found that the effect of atropine on endometrium is identical with that of estrogens in halting rhythmical vasoconstrictions and in failing to affect myometrial contractions in any predictable manner. Atropine does not inhibit the effect of estrogens on endometrium, despite the fact that it is a powerful acetylcholine inhibitor. Furthermore, stilbestrol, which Reynolds found does not cause a rise in ace-

tylcholine content of the castrate rabbit uterus, produces an endometrial effect identical with that of sodium estrone and amniotin. It seems likely that Reynolds was measuring changes in acetylcholine in the myometrium only, especially since myometrium forms the bulk of the castrate rabbit uterus. Unless these effects are a species peculiarity of the rabbit, the acute effect of estrogen on the endometrium is not mediated by changes in endometrial acetylcholine.

SUMMARY

1. The physiological activity of uterine tissues can be observed in intraocular transplants. Endometrium maintains its histologic integrity in grafts and myometrium grows at the main site of attachment in bundles surrounding the vascular supply of the endometrium. Myometrial contractions can be identified by the motion and the occlusion of blood supply which they produce. The blood vessels of the endometrium undergo rhythmical vasoconstriction in nonpregnant mature animals.

2. In the rabbit, atropine causes a slowing or cessation of endometrial vasoconstrictions but does not predictably affect contractions of myometrium. Estrogens produce a slowing or cessation of endometrial vasoconstrictions and a dilatation of endometrial vessels but do not affect myometrial contractions. The administration of atropine does not alter the endometrial responses to estrogens regardless of time relationships.

3. These observations necessitate revision of the cholinergic concept of the effect of estrogens on the endometrium.

The histological sections were prepared by Mr. Joseph P. Drane and photographed by Mr. Chester Reather. The drawing was prepared by Mrs. Jeannette M. Whitehorn.

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A MULTI-CHANNEL STRAIN-GAGE TOKODYNAMOMETER: AN INSTRUMENT FOR STUDYING PATTERNS OF UTERINE CONTRACTIONS IN PREGNANT WOMEN[1]

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1. REQUIREMENTS OF A TOKODYNAMOMETER

Uterine inertia is one of the chief problems facing the obstetrician today. It is a condition which is recognized only by its occurrence since there is nothing in a clinical history which presages its imminence. Uterine inertia, however, presents but one aspect of a general problem which confronts the obstetrician, namely, that of uterine dyskinesias during labor. These include the clinically recognized dystocias, contraction rings, and prolonged types of labor. The identification of these clinical entities is still a matter of clinical recognition as they occur. No physiological basis has yet been established for them. This is, accordingly, an important field for clinical and physiological investigation.

Perhaps the greatest lack in our knowledge of these conditions is that of a description of the basic patterns of uterine contractility in women before and during labor. A method is urgently needed which will enable us to visualize the origin and spread of the uterine contractions in order that we may associate different contraction types with different clinical conditions. This paper contains a description of an apparatus which makes this possible.

It is true that much is known concerning the comparative aspects of the activity of the uterus in labor. This subject was extensively reviewed eight years ago (Reynolds, 1939). There have been numerous studies of motility of the human uterus during labor, in addition to comparative studies. These are of three types: namely, (a) those concerned with direct measurements of intrauterine pressures (Schatz, 1871–72, Rucker, 1922, Woodbury, Hamilton and Torpin, 1938, and

[1] A preliminary note on the tokodynamometer appeared in Science for October 31, 1947 (Reynolds, Heard and Bruns).

others); (b) those concerned with measurement of the frequency of uterine contractions from the exterior of the abdominal wall by means of a single tokograph. All such units thus far used are so made that they record the activity at only one point. The Lorand tokograph employed extensively by Murphy (1946) is the tokograph most favored in recent years. The third method (c) is that of electrometric measurements of uterine action potentials. This method has not proved to be satisfactory in so far as the gravid uterus is concerned (Dill and Maiden, 1946).

The difficulty inherent in the foregoing methods is that they fail to yield information concerning the origin and spread of the uterine contractions. Instead, they give limited information concerning the expulsive force of the uterus or the frequency and duration of the contractions at a single point.

The ideal method would combine these features into one unit. The instrument described in this communication is the result of an attempt to design such an instrument. It is characterized by ease of operation and simultaneous multichannel electrical recording through the abdominal wall from three separate parts of the uterus. No photographic, ink-writing or kymographic procedure in the usual sense is employed. Instead, the instrument described below and shown in figure 1 records electrically on a single piece of moving paper the uterine activity during the latter months of pregnancy. The principle employed involves application of the strain-gage dynamometer to direct electrometric recording through frictionless writing. The key to this method is the specially devised pick-up which makes it possible to apply a strain-gage of known characteristics to the abdomen. Since three records are obtained on a single piece of paper, it is possible to measure simultaneously the characteristics of single contractions ((1) contraction-time, (2) relaxation-time, (3) contraction-rate, (4) force applied through the abdominal wall on the pick-up to the active element of the strain-gage), and to compare the time relations of any part of one contraction with the activity at either of the other two points simultaneously.

2. NAME OF RECORDING UNIT

The unit just described has been named a *tokodynamometer*. This word is taken from Websters' New Unabridged Dictionary. The

word is a compound one derived from the two following roots: *toko*, meaning "pertaining to birth"; *dynamometer*, indicating "measurement of force." While the complete descriptive name of multiple channel tokodynamometer is cumbersome, it lends itself to abbreviation by the convenient letters TKD. The records obtained on the TKD are tokodynagraphs, or TKGs.

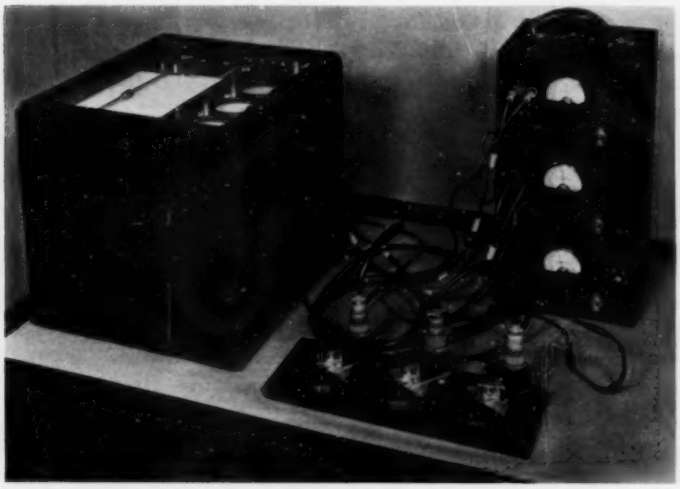

FIG. 1. PHOTOGRAPH OF TOKODYNAMOMETER: THREE STRAIN GAGE PICK-UPS, POWER SUPPLY (RIGHT REAR) AND FRICTIONLESS ELECTROMETRIC WRITING UNIT (LEFT)

3. CONSTRUCTION

The several parts of the TKD now in use by us are as follows: *Strain gage pick-ups*. Statham strain gage dynamometers (Statham Laboratories, Los Angeles), either model YE-4-250 or model Gl-4-250, are used. These yield maximum electromotive output with 4 ounces of pressure. The maximum movement of the pin and active element of gage is ± 0.0015 inch. The dynamometer has relatively high frequency characteristics and the output is linear with the stress applied.

The YE model was first used as the only available dynamometer suitable for our purpose. It is the one shown in the illustrations. It has been replaced for several reasons however by the Gl model which

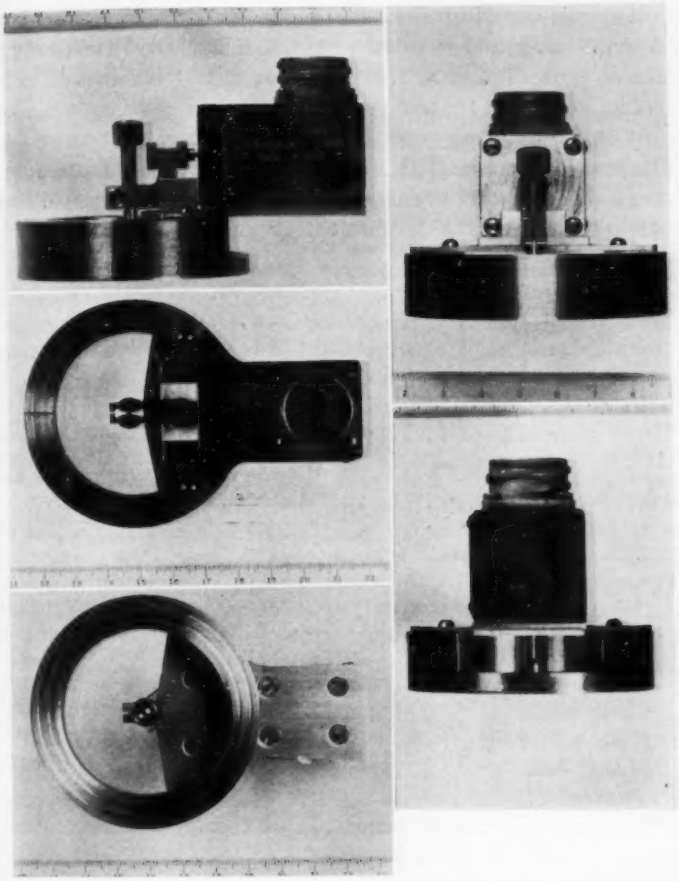

FIG. 2. PHOTOGRAPHS OF THE MODEL YE-4-250 STRAIN GAGE DYNAMOMETER MOUNTED ON THE BRASS RING AND LEVER USED FOR RECORDING UTERINE CONTRACTIONS

a, side view; *b*, top; *c*, bottom; *d*, front; *e*, rear

has identical electrical and tension characteristics. The Gl model is thinner, lighter, and it has no Cannon plug. As a result, it makes a better balanced unit than does the YE model dynamometer.

The strain gage is mounted on a heavy brass ring (see figure 2 a, b,

b, c, d, e) weighing 240 grams. The pin of the strain gage is connected by a simple lever system to an adjustable plunger held vertically, as shown in figures 2 and 3. A stainless steel ball is mounted in the socket at one end of the plunger. Details of the connection between the pin on the strain gage and the lever are shown in the figure 3.[2]

The essential feature of this unit is that it enables the operator to set the lever at a proper working level without putting a residual strain on the pin, so making it unsuited for use. At the same time,

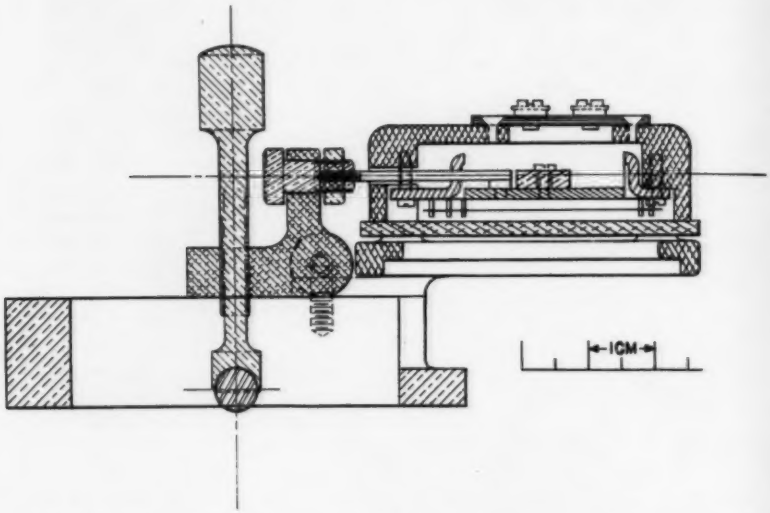

FIG. 3. DETAIL OF INTEGRATION OF THE DYNAMOMETER WITH THE ADJUSTABLE LEVER USED TO RECORD DIFFERENTIAL PRESSURE BETWEEN THE PLUNGER IN THE CENTER AND THE CIRCUMFERENCE OF THE RING

the knurled nut on the screw which binds the lever to the pin can be tightened securely. This holds the lever firmly in place

The development of the pick-up just described was the result of a series of failures. In the first attempt, the gage was mounted vertically on a plate with a brass

[2] Patterns for the ring, the mounting for the gage and the lever have been made. These units are available through the Department of Embryology, Carnegie Institution of Washington, Wolfe and Madison Streets, Baltimore 5, Md. Attention: O. O. Heard.

button on the end of the pin. This button could be adjusted on the abdomen through a hole in the base plate on which the gage was mounted. There were two drawbacks to this arrangement. The unit had such a high center of gravity that it was difficult to secure it on the abdomen, and the uterine contractions tended to work on the pin in a sidewise manner. As a result, uneven records were obtained and eventually the pin was loosened at its soldered joint within the gage. In contrast to this, the lever adopted for use in the pick-up shown in figure 2 serves to eliminate all pressure on the pin except that in an in-and-out direction.

A second method which proved unsatisfactory was that of mounting the gage on its side on a large, light oval aluminum base plate. The dynamometer pin was integrated with the lever now in use. The plate was held in place on the abdomen by strips of adhesive tape. The disadvantage of this was that pressure within the abdomen anywhere along the line of the adhesive tape strips resulted in a change of pressure on the plunger. It was clear from trials with this arrangement that the plunger should touch the abdomen in the center of a circle, and that the area of attachment to the abdomen should be the circumference of the circle. Accordingly, Masonite rings were made with circular cut-outs ranging from two to seven centimeters. By trial and error it was found that rings having a hole 5 centimeters across and a total external diameter of 7 centimeters served best the requirements of sensitivity and compactness. In order to achieve stability, however, the levers and the gages are mounted upon the brass rings shown in figure 2. In this way, the center of gravity is low, and there is sufficient mass to permit development by the uterine contractions of an adequate differential of pressure between the ring and the plunger in its center. A cut-out is made in the brass ring on the side to which the gage is attached to offset the overhanging weight of the gage, as shown n figure 2.

In operation the ring is held in place on the abdomen by application to its underside of a layer of double-coated Scotch tape, as will be described in greater detail below. As a result, only the tape-covered area under the brass ring and the plunger touch the abdomen.

Recorder. The recorder was designed and made to our specifications by the Electro-Physical Laboratories, New York City. This consists of three channels (see figure 4), each of which contains a modified Weston Model 699 microammeter connected directly to the indicating leads from the strain gage. The needles of the galvanometers are extended by fine quartz tubing (just discernible in figure 4 as each extension passes under the black bar in front of the meters) cemented to their tips and projecting through a cut-out in the case. On the tip of each quartz extension a short (2 millimeters) piece of 36 gauge nichrome wire is cemented, like the cross of a *T*, in a vertical position. This occupies a position between two plates, over the bottom one of

which passes the specially treated heat-sensitive (Permograph) paper shown in figure 4. When the recorder is running, sparks pass from the top plate under the black bar through the nichrome tip to the bottom plate. In passing through the paper, the sparks burn a hole about the size of a pin point. A distributor in the recorder sends sparks

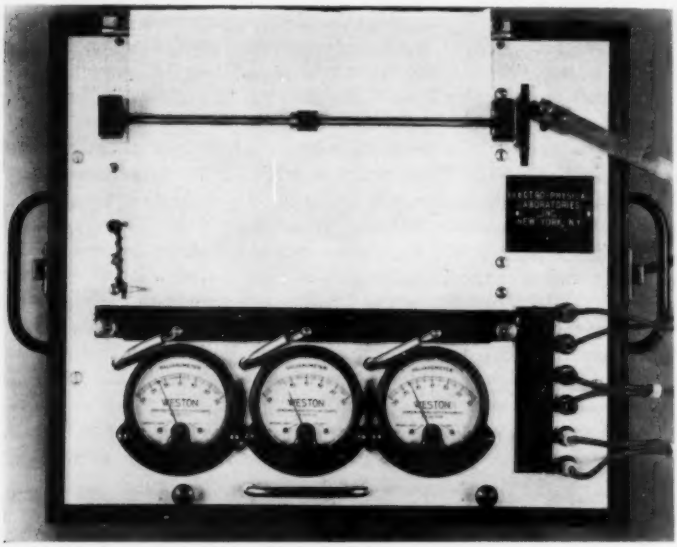

FIG. 4. VIEW OF TOP OF THE RECORDING UNIT OF THE TOKODYNAMOMETER WITH THE PLASTIC COVER REMOVED

Frictionless writing is achieved by sparks passing from the black bar through the heat sensitive paper to the metal plate beneath. The sparks pass through wire tips on the quartz extensions of the microammeter needles. (See these as they pass under the black bar to the left of the spark-distributing wire in each channel.) Two paper speeds are available by means of the lever at the upper right. Time marker is at the left end of the black bar.

through each of the microammeter tips twice a second. Time intervals are marked at the bottom of the paper by means of a heated sapphire point which drops down and touches the paper once every minute. Two paper speeds of 5 and 25 millimeters per minute are available. The tips of the ammeters swing freely without touching

either the metal of the bar above or the paper beneath. The TKD is, therefore, a direct-recording frictionless writing system. The instrument is so sensitive that the top of the recorder is enclosed in a plastic case during operation of the instrument in order to protect it from air currents.

The records of uterine contractility consist of a series of fine holes burned through the paper under each nichrome tip according to its position at the instant of sparking. This position depends upon the amount of pressure applied to the plunger, up to the maximum limit of the gage.

Other types of recorders obviously can be used with the pick-ups which we have devised. For example, it has been ascertained that an ink-writing, two-channel magnetic oscillograph recorder made by the Brush Development Company, Cleveland, works as well as the one described above except that it has one less channel. It consists of one DC amplifier for each channel (number BL 913) and one double channel magnetic oscillograph (number BL 202) modified by adding a slow speed motor (10 r.p.m.).

Power supply and control. Two systems of supplying current input to the strain gages have been used satisfactorily. In both, the input is derived from a 6 volt A battery. In the unit shown in figure 1, the current is controlled by a 200 ohm variable resistance, a 0 to 50 milliammeter and a switch. The output from each gage goes directly to one of the microammeters on the recorder. In the second control circuit, the wiring diagram for a single circuit of which is shown in figure 5, additional features were supplied by the Statham Laboratories. These features simplify the standardization and zero adjustment of the circuit. The zero adjustment potentiometer is used in our TKD to set the needles of the galvanometers at a setting of -14. In this way, distortion of the record resulting from the radius of curvature of meter needle is minimized. Operation of the standardizing circuit is so designed that it causes a deflection of the microammeter needle equal to one-half the maximum output of the gage. That is to say, a deflection is obtained which is equal to a pressure of two ounces on the pin of the strain gages used in the TKD. By this means the sensitivity of each channel can be adjusted to match the sensitivity of the other two.

The power supply for the Brush Magnetic Oscillograph, when used as part of a TKD, differs from the foregoing in that it does not have a zero adjusting mechanism since this is incorporated in the DC amplifier. Sensitivity control is also available in the amplifier, but the standardizing switch for half the gage output is retained for purposes of electrometric calibration.

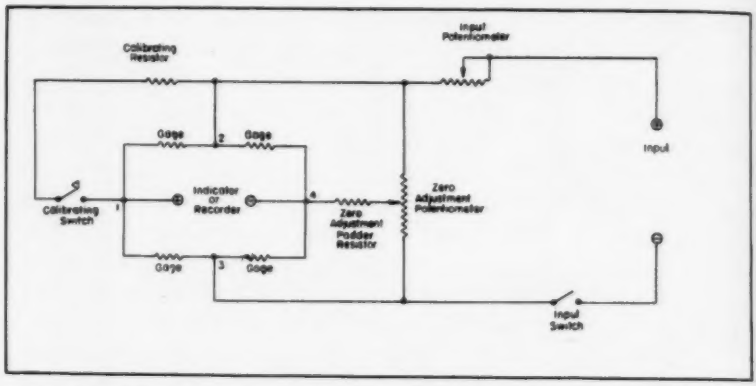

FIG. 5. WIRING DIAGRAM, SCHEMATIC, OF THE CONNECTIONS IN A SINGLE CHANNEL OF THE TOKODYNAMOMETER

Details of the power input control were supplied by the Statham Laboratories.

4. OPERATION

In operation, the tokodynamometer is mounted on a movable table in order that it may be wheeled near the bedside of a patient.

The patients are normally in a supine position for recording, although records have been obtained from patients lying on their sides. In some instances, when vomiting, retching, or straining occurred, the records of uterine activity have been little disturbed, and then only during the period of greatest bodily activity. If records are to be made from the lower uterine segment, the bladder of the patient should be emptied. In very hot weather, it is necessary to wipe perspiration from the abdomen with alcohol immediately prior to application of the pick-ups.

When recording, the gages are secured to the abdomen at the sites of

choice simply by coating the underside of the brass ring of the pick-up with double coated Scotch masking tape, one-half inch wide, as mentioned before. This tape is applied to the ring by taking a six or seven inch length of tape from a dispenser, applying a short length along the under surface of the ring, turning the tape over diagonally to fit the curve and laying down a second short length along the surface. This process is repeated until the entire under surface has been circled once and so is completely coated with tape.

The position the gages will occupy on the abdomen is determined after noting the size, shape, and position of the uterus. A record of this is kept in the following manner: Each pick-up is placed in one of nine standard positions on the abdomen. The distance from the symphysis pubis to the highest point on the fundus is measured and divided into thirds. These three transverse areas are in turn divided into three more by measuring five centimeters on each side of the mid-line of the uterus. Since the brass rings are seven centimeters across, they fit with about one-and-half centimeters on each side when placed in the middle of one of the rectangular areas. The standard areas across the top (fundus) for recording TKG's are designated A, B, and C. Next, across the middle of the uterus, D, E, F and across lower uterine segment, G, H and I. The advantage of employing these fixed areas is that it is possible to classify the data for statistical analysis. In addition, the distance from the top margin of the symphysis pubis to the costal margin directly cephalad is noted. After attachment of the pick-ups, the plungers are adjusted so that the needle of each microammeter is just slightly deflected. At this point, the radius of curvature of each of the needles is recorded by sparking on a stationary paper as the paper-speed switch is set in the neutral position. One or two uterine contractions or manual pressure on the pin of the strain gages will suffice for this. The sensitivity of each channel is fixed to match the others by adjustment of the different input currents in the three channels. With the recorder set to operate at either of the desired paper speeds, turning of a single switch on the recorder starts the paper moving and the sparking mechanism begins to record. Records lasting for periods of time up to four hours and more have been obtained with minimal inconvenience to the patient. During the recording period, the patient may talk, cough, or even change her position somewhat

FIG. 6. Top, view of abdomen with nine areas of the uterus described in text indicated by letters A, B, C, etc. In practice the areas are not drawn on the skin, but are determined by the eye.

Bottom, view of the same area shown above with strain gages in place for recording.

without interference to the record of uterine contractions. Moreover, routine rectal and vaginal examinations may be carried out as well as catheterizations without affecting the record appreciably. The deflections of the galvanometer needles associated with such activities are very transient, or they cause merely a slight shift in the base line. The rhythm of coordinated uterine activity continues without real interruption, and may be both observed or felt by palpation to coincide with the record obtained on the TKD.

TABLE I

List of clinical data included on two hand-stamps which are stamped on each TKD tracing as a matter of record

In addition, an outline of the female torso is stamped on each tracing and the locations of the gages are indicated on this in accordance with the nine areas shown in figure 6.

Name	Admitted
Age	Onset L.
Hist. No.	Membr.
Date	Bleeding
Race	Toxemia
Ht. Wt.	T. P. R.
Parity	Sts. Rh.
L. M. P.	Pelvis
E. D. C.	Pelvimetry
Dur. Wks.	F. H.
Hist. & Rx.	Est. F. Wt.
Exam.	Anes.
Hour	Delivery
Pres. Part.	Duration
Membr.	Child Wt.
Dil.	Add. Notes
Eff.	
Pains.	

The limitations of this method found thus far are that it does not lend itself well to use in very obese patients, and that it does require a limited amount of cooperation on the part of the patient. The latter may be assured in prolonged observations during labor by administering caudal anesthesia.

5. RECORDS

Clinical data. All pertinent clinical data are summarized at the beginning of each tracing. The use of three rubber stamps facilitates

this. A stamp of the torso makes it possible to draw in proper proportion and position the outline of the uterus. The positioning of the pick-ups is similarly marked in the manner described above. The other two stamps permit easy tabulation of all pertinent clinical data as part of the record itself. The abbreviations and symbols used are

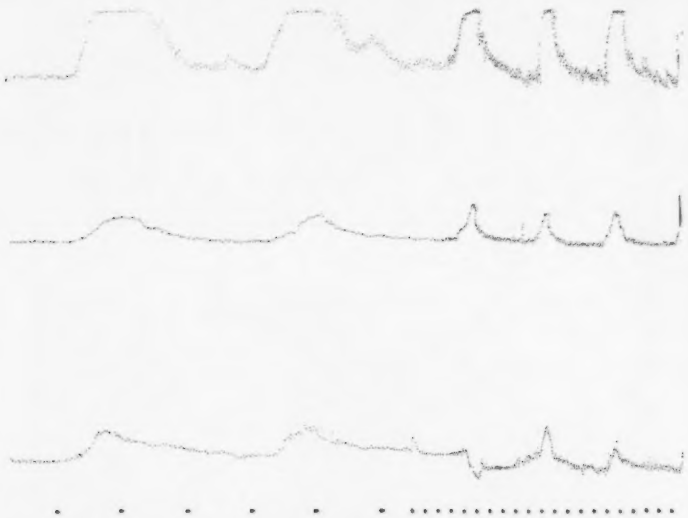

FIG. 7. SAMPLE OF AN UNRETOUCHED TKG, REDUCED ABOUT ONE-HALF

Note the series of fine holes which make up the tracings. Time intervals, 1 minute. The effects of respiratory movements are seen, especially in the upper tracing. Top, fundus recording; middle, over the navel; bottom, lower uterine segment.

the conventional ones employed in the records of the Department of Obstetrics, Johns Hopkins Hospital.

Characteristics of tracings. Examples of sample records are shown in figures 7, 8, 9 and 10. In the first, a section of unretouched record is shown on a slightly reduced scale. The fineness of the holes which make up the three tracings does not permit photographic reduction. When it is necessary to reproduce any length of record photographically the record may be retraced by a ball point pen. This gives a clear

FIG. 8. GREATLY REDUCED PICTURE OF A TKG TRACING FROM FIRST STAGE OF LABOR

In order to reduce this for reproduction, it is necessary to trace over the record with ink. This is conveniently done by means of a ball point pen. Effect of pituitrin, ½ minim intramuscularly, is shown at arrows. Bottom, fundus; middle, at navel; top, lower uterine segment. Note the effects of vomiting, just before the break in the record. Record was continuous, but about 40 minutes of recording have been eliminated. Note also the gradual subsidence of the activity in the middle record as cervical dilatation passed from 9 to 10 centimeters. Compare with figure 10.

record which will stand very marked reduction, as shown in figures 8, 9 and 10.

Several features of these records require comment. The record, as we have seen above, is made by a series of holes burned by sparks discharged at half second intervals. Because of this the effect of artifacts on the record is interesting. If the fetus kicks or turns, or the

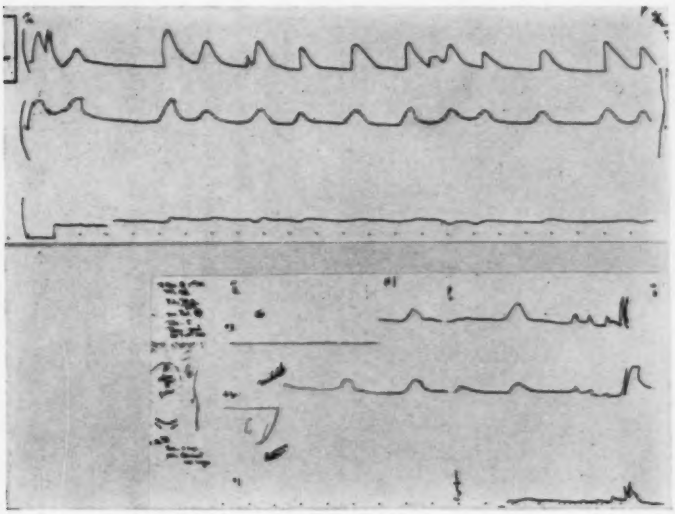

FIG. 9. THE FIRST STAGE OF LABOR AND ONSET OF THE SECOND

The first part of record was from 11:15 to 11:40 a.m. Cervical dilatation, 1 centimeter. At 2:15 p.m. the cervix was dilated 5 centimeters. Pick-ups were placed on same spots as before. With full dilatation at end of record, note onset of reflex abdominal movements in all three tracings.

patient coughs or moves, only one, two, or three single small holes are burned off to one side of the orderly series of holes which record the slower uterine movements. In the records obtained with the TKD described in this paper, it is difficult, therefore, to detect such artifacts. Only when they are sustained for a number of seconds are they easily discerned.

The effects of respiratory movements are likewise of interest. Between uterine contractions, when the indicators are near the base line,

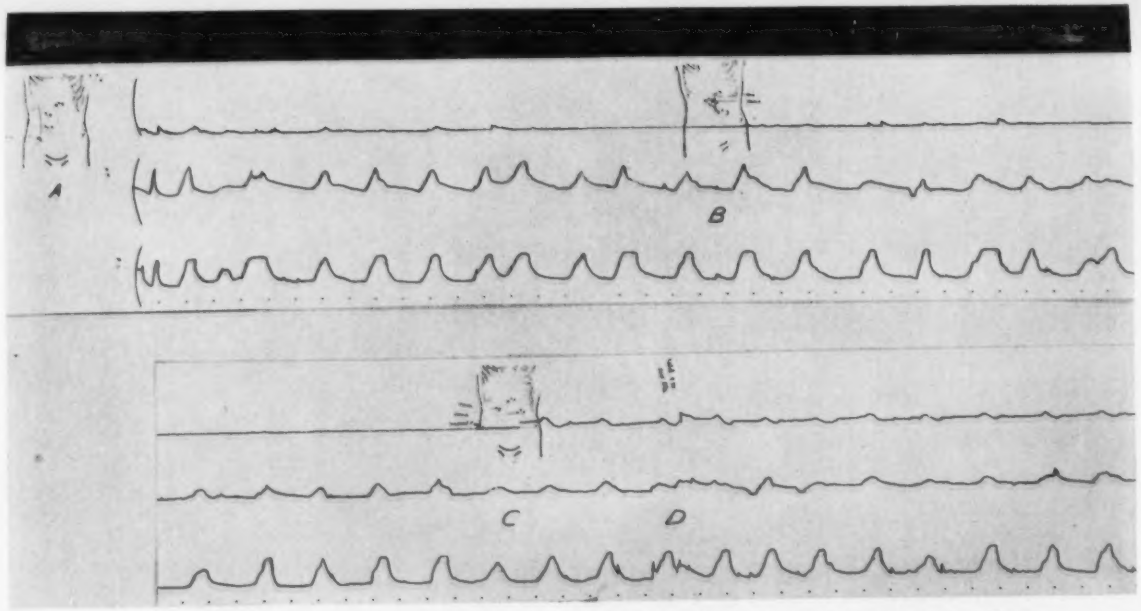

FIG. 10. CHANGE IN ORGANIZATION OF PATTERN OF UTERINE CONTRACTIONS IN THE FIRST STAGE OF LABOR

Record shows activity in the fundus at the bottom; in the middle of the uterus near the navel, and at the top, just below the navel in the lower uterine segment. Except for slight shifts of the last to a position nearer and nearer the middle pick-up, no change in the position of the strain gage was made. Observe the progressive subsidence of the activity at the mid-point of the uterus, so that at the end only the fundus is contracting forcibly. Cervix dilated 1 cm. at start, 2 cm. at end. Record terminated at 12:35 p.m.; spontaneous delivery at 3:09 p.m. Compare with figure 8.

slight movements may be seen occasionally in the channel or channels recording from the fundal portion of the uterus. The effect on the record is to make a line several holes wide as a result of regular oscillations of the microammeter needle which moves through an arc of about one to two millimeters in length. This may be seen in figure 7 in the lead placed over the fundus. During a uterine contraction, the increase in tension on the gage is sufficient to mask completely this slight respiratory effect which is seen when the uterus is relaxed.

Analysis of records. The individual tracing in any one channel is analyzable for the usual time and intensity characteristics of muscle contractions. A specially constructed calibrating board to be described facilitates the analysis of these features. These include, a) frequency of contractions, b) rhythmicity or regularity of contractions, c) relative intensity at the point of recording, d) contraction time, e) total duration of the contractions, f) rates of contraction and relaxation (i.e., slopes of the curves) and g) total relative work per unit period of time. The pattern of activity exhibited by the uterus as a whole may be judged by comparison of the records in the three channels with each other, particularly with respect to their time relations.

The evaluation of the records obtained on the TKD for the above-mentioned points has been solved in the following manner:

a) *Frequency of contractions.* This presents no problem. The number of times the uterus contracts per hour may be measured for records of relatively short duration.

b) *Rhythmicity.* This is determined by measuring the interval of time between the points of onset of successive contractions in a series. The data should be examined, after tabulation, for existence of a trend. If this exists, the fact is noted. If not, and there are sufficient data to warrant it, the data may be treated statistically and analyzed for the standard deviation, standard error of the mean, and so forth.

c) *Total relative work per unit period of time.* This aspect of a tracing may be worked out in the conventional manner, using the planimeter. The sum of the areas between the onset of contraction and the beginning of relaxation under all curves are determined in a given period of time. Since the strain gages are calibrated in grams of force applied to the pin on the gage, any change in the areas under the curves may be determined as a change in work during the contraction phase of a contraction. This may be computed in grams or ergs on an hourly rate or for any other convenient interval of time.

d) *Characteristics of contractions.* The conventional method of assessing the

contraction-characteristics of uterine contractions in a tracing is by simple inspection. Much may be learned by this. For example, a trend in the change in the height (strength) of contractions may be evaluated approximately. The essential thing to remember in this, however, is that the records obtained by the method described in this paper yield limited information: they indicate the change in pressure (i.e., curvature) between the center of the brass rings of the pick-ups and the circumference of the holes in the rings. Consequently, it is difficult to see how any estimate of changes in tonus may be recorded.

A more quantitative way of evaluating the different features of the tracings has been devised. It involves the use of an easily constructed board and a flat piece of Lucite, 6 x 9 inches in width and length respectively. As mentioned before, simultaneous ordinates are laid down in the three channels on the stationary paper. This is to provide a record of the radius of curvature of each of the writing arms and to indicate the position of the time marker at the same time. When the record is ready for study, it is laid flat on the calibrating board with the bottom edge of the paper flush with a raised edge at the bottom of the board. The Lucite sheet is then placed over the paper, its bottom edge held firmly against the raised edge of the board. Lines are drawn with a glass-writing wax pencil over each of the simultaneous ordinates on the tracing. Cross marks are placed on these at 5° intervals for the radius of curvature of each ordinate. This distance has been found in our TKD to be equal to a force of 10 grams applied to the pin of the gage. Either a mark is made over the location of the time marker for the simultaneous ordinates, or the edge of a small cut-out in the Lucite is held at the time mark which is made when the simultaneous ordinates are laid down. It is then possible to analyze certain features of the tracings of the tokodynagraphs in the following manner:

(1) *Intensity of contractions.* The point on a particular ordinate at which the uterine contraction commences is noted. The piece of Lucite is then moved to the right until the peak of contraction is reached, the paper and the Lucite being held firmly against the bottom edge of the calibrating board. The distance on the ordinate between the first and the second point shows the force exerted against the pin of the strain gage. As mentioned, this may be read in grams of force.

(2) *Contraction-time.* This may be determined by marking on the time line of the paper the moment of onset of a contraction, using the simultaneous ordinates on the Lucite sheet as a guide and the moment corresponding to the peak of the contraction. The distance between these in minutes or fraction thereof may be estimated with a fair degree of accuracy. For this determination, it has been found that the paper speed at the time of recording should be at least one inch per minute.

(3) *Contraction duration.* This feature may be determined by similar use of the calibrated simultaneous ordinate marker described above. The appropriate distance along the time line from the beginning of contraction to the relaxation phase are noted in the same way that the contraction time is determined. Our

TABLE II

Analysis of the records shown in figure 10

Spontaneous delivery, duration 13 hours. Record begun 6 hours before delivery. Cervix dilated 1 cm. At end of third time period shown in table (after 49 minutes of recording) the cervix was dilated 2 cm. Position of gages: B, mid fundus position; D mid uterus, right of center; H, mid lower uterine segment. See text for system of placing the gages on the abdomen.

CHARACTERISTICS OF CONTRACTION PATTERN									CHARACTERISTICS OF INDIVIDUAL CONTRACTIONS												
Frequency (minutes)			Work ergs					Gradient conduction time B-D (seconds)	Intensity (grams)			Contraction time (seconds)			Duration of contraction phase (seconds)			Mid uterus: fundus ratio, %	Rate of contraction (grams/second)		
			Per contraction		Rate per hour																
			B	D	H	B	E		B	D	H	B	D	H	B	D	H		B	D	H
Contraction intervals (minutes)	Average for period	Rate per hour	Fundus	Mid uterus		Fundus	Mid uterus		Fundus	Mid uterus	Lower segment	Fundus	Mid uterus	Lower segment	Fundus	Mid uterus	Lower segment		Fundus	Mid uterus	Lower segment
1.2			518	518				0	45	45	10	20	24	20	38	24	16	64	2.5	2.1	0.4
1.8			2,520	260				6	40	30	8	26	24	20	26	32	0	123	1.5	1.2	0.4
2.0			1,080	604				5	42	38	0	28	20	0	44	20	0	45	1.5	1.9	0
2.0			650	432				5	48	35	8	30	24	24	42	33	8	76	1.6	1.4	0.3
2.0			778	562				0	42	38	0	32	28	0	42	27	0	64	1.3	1.3	0
1.2			604	310				0	38	35	0	35	43	0	55	48	0	87	1.1	0.8	0
2.3			1,685	216				8	42	28	0	38	28	0	38	28	0	73	1.1	1.0	0
1.6			906	390				12	45	36	0	28	16	0	55	16	0	29	1.6	2.2	0
2.3			1,290	432				8	40	30	0	28	24	0	40	24	0	60	1.4	1.2	0
2.0			1,168	604				15	48	40	5	36	22	12	56	22	0	40	1.3	1.8	0.4
2.1			864	216				18	48	36	3	48	30	12	56	36	20	64	1.0	1.2	0.2
Aver., 20 min.....	1.8	33	1,100	413		33,300	13,600		43	35	3	32	26	11	45	28	4	62	1.45	1.46	0.1

2.6			778	130				8	48	15	0	32	26	0	60	26	0	43	1.5	0.6	0
2.1			2,460	346				8	50	15	0	20	16	0	28	16	0	57	2.5	0.9	0
1.5			518	216				20	48	28	0	56	32	0	36	32	0	89	0.8	0.7	0
2.3			562	260				8	28	18	0	44	40	0	96	40	0	41	0.6	0.5	0
2.0			735	173				12	28	13	0	50	32	0	50	32	0	64	0.6	0.4	0
3.3			820	216				6	40	20	3	27	32	12	36	32	0	89	1.5	0.6	0
2.6			562	173				16	48	15	0	36	29	0	36	29	0	80	1.3	0.5	0
1.8			1,040	216				0	45	20	0	22	24	0	40	24	0	60	2.0	0.8	0
2.3			1,124	260				8	45	20	0	22	20	0	40	20	0	50	2.0	1.0	0
Aver., 20 min.....	2.3	27	780	181		21,200	4,900	9	42	18	0	34	28	1	47	28		59	1.42	0.7	0
2.2			650	130				36	34	10		58	36		58	40		69	0.6	0.2	
1.6			996	130				10	42	10		40	32		40	32		80	1.0	0.3	
2.3			1,166	260				10	46	18		52	44		60	49		81	0.9	0.4	
1.8		(3,916)	604	216				8	40	13		40	28		46	38		82	1.0	0.4	
Aver., 9 min.....	1.9	26.6	856	184		23,000	4,900	16	32	13		47	28		51	40		78	0.9	0.4	
2.1			310	173				12	25	9		34	22		34	28		82	0.7	0.4	
2.1			1,040	130				10	42	12		34	22		50	34		68	1.2	0.5	
2.2			562	260				15	48	12		40	30		40	44		110	1.2	0.4	
2.2			864	310				6	45	14		36	18		36	38		166	1.2	0.8	
1.9			735	86				12	46	10		33	24		40	24		60	1.4	0.4	
Aver., 12 min.....	2.1	25	702	240		18,000	6,000	11	41	11		35	23		40	36		90	1.1	0.5	

experience to date suggests that the relaxation time is probably of little significance. The reason is that, while the contraction phase is due to displacement caused by the uterine contraction, the relaxation is made up of readjustment of abdominal viscera upon cessation of the uterine contraction. The curve of relaxation is complex, frequently consisting of an initial quick component and of a slow phase of very irregular outline.

(4) *Contraction rates.* The slope of the contraction phase is determinable as follows: the height of the curve, in arbitrary units or in grams, is divided by the contraction-time or the relaxation-time, respectively. In this way, the rate of contraction may be compared during a record and in different parts of the uterus simultaneously. Thus the degree of dissipation of the contraction may be judged very easily in a quantitative manner.

e) *Gradients of activity.* These may be determined very easily and accurately by the use of the Lucite calibrating device described above. The reader may be assured that it is impossible to determine gradients of activity by simple inspection of the record. The procedure we have adopted is as follows:

The moment of onset of contraction in channel #1 is noted on the time abscissa. Similarly, the corresponding contraction in channels #2 and #3 is noted. The differences between these several points indicate the time required for uterine contraction to travel from one gage to the other two, in order. Similarly, gradients of relaxation also may be determined in this way. By appropriately placing the pick-ups on the abdomen and keeping a careful record of the position with the aid of the rubber stamp showing the outline of the torso, described above, it is possible to determine directly, and for the first time, the nature of the pattern of uterine activity in women before and at term and to correlate these positions with the several types of uterine dyskinesias and clinical courses of labor. Our experience to date suggests that the gradient of contraction exists, but that other aspects of the contraction curve of the uterus are more accurately determinable and just as useful.

Examples of each of the above types of analyses are given in table II. These are data taken from a record (figure 10) of normal spontaneous delivery without complications. It is probable that, as additions are made to these data in the future, different values will be obtained since these will be based upon statistical analysis of data from many cases. The present data are offered merely as representative from an individual tracing while the work of gathering numerous data goes on.

DISCUSSION

Several points remain to be discussed in connection with the general aspects of the tokodynamometer and the records which it yields.

In the first place, one may question in what way the records obtained with the TKD differ from those obtained with the Lorand tokograph. One might suspect that, except for the fact that the latter gives but one tracing and the former three, the tracings are essentially similar.

In a fundamental way, however, the two instruments differ markedly from each other. In the TKD, the pick-up shown in figure 2 and described in the text records the force transmitted through the abdomen exerted by the uterus as it changes shape (i.e., the force behind the change of radius of curvature under the brass ring of the pick-up); in the Lorand tokograph the method of applying the unit to the abdomen virtually precludes such localization of effect. It is held in place by means of a strap passed around the body. The instrument can be acted upon, therefore, by any force which tends to alter the length of the circumference of the body under the strap. Local uterine movements do dominate the situation, of course, but it is equally true that remote uterine effects as well as fetal movements, shift in fetal position, or other movement within the area circumscribed by the strap may affect the amount of pressure upon the lever of the tokograph. This, in fact, is what we observed when we first applied our strain gage pick-ups with long strips of adhesive tape. By limiting the adherent surface of the unit to the under side of the brass ring, we procure changes in pressure on the active portion of the gage which are purely local in character.

A second question which may have occurred to the reader, and one which certainly has been of some moment to the authors, pertains to the advantage of, or necessity for, three channels for recording. Would not two channels suffice? It is too early to give a final answer to this question. No doubt for many purposes, especially that of judging the effects of oxytocic and uterine sedative drugs, two channels may serve as well as three. Experience has shown us, however, that there are definite times when three channels yield information not available with two channels. For example, we have seen instances of strong, regular contractions in the uppermost part of the uterus and none in the lower uterine segment in the first stage of labor. This continued throughout the record, but it was associated with strong contractions in the midportion which underwent progressive diminution to quiescence as the first stage of labor progressed. Again, we have seen one instance in our limited series of observations, so far, of good dilatation of the cervix in a multiparous woman in which the whole lower half of the uterus was virtually inactive, and the labor was accomplished almost entirely by means of strong, regular contractions in the uppermost portion of

the uterus alone. When we have observed hundreds of cases instead of the five dozen which have been obtained up to the present time, a full, detailed account of the patterns of uterine contractions in different types of labor will be presented. It is evident already, however, that this will be made possible only by means of the three channel TKD now available.

Still another advantage of the three channel unit is that it may well be adapted to somewhat different purposes. For example, it is entirely feasible to connect one channel with a balloon placed in the lower uterine segment during the first stage of labor and employ one of the Statham pressure recording dynamometers (model P8, P6, or P23, with a sensitivity of 2.5 or 6.0 pounds per square inch) for activation of one microammeter. The other two channels may then be used for recording externally the activity of the uterus at two points. In this way, the contractility patterns may be correlated with the force which is dilating the cervix.

In conclusion, a final word may be said concerning the technical aspects of the construction of the TKD. The unit made for us by the Electro-Physical Laboratories serves our present purposes admirably. It has several inherent drawbacks, however: it is relatively large, it is delicate, and the meters are fragile. The records are large, on unlined paper, and are inscribed with a distorting radius of curvature. If a TKD is to be devised for general research, teaching, and clinical uses, it is desirable that it yield records which are rectilinear, on lined paper requiring no photographic procedure, and that the unit be compact and sturdy. The Brush Development unit described in this paper possesses many of these features. It is only a two-channel recorder, however, and there is just as much distortion of the records from the writing levers as there is in our present TKD. It appears that a unit operating on the principle of the heat-writing, rectilinear magnetic oscillograph found in the Sanborn Viso-Cardiette would serve the purpose ideally, except that the unit must be modified to integrate with the direct current Statham gage. It should have slow speed recording and three channels instead of one. It will be worthwhile developing such a unit only if extensive results with the present pilot model indicate that there is a very wide range of usefulness for the TKD in many obstetric clinics.

SUMMARY

1. An instrument has been designed to study the basic patterns of uterine contractility in women before and during labor. In principle it consists of application of strain-gage dynamometers to the abdomen with direct electrometric recording on an electric-spark frictionless recorder. The instrument is called a tokodynamometer or *TKD*.

2. It has an advantage over previous instruments in that it permits study of the origin and spread of uterine contractions. Its construction and operation are not complex. Three Statham strain-gages mounted on brass rings 5 cms. in diameter are secured to the abdomen by double-coated Scotch tape. The plungers are adjusted so that the microammeter needles will deflect with the onset of uterine activity and record by sparks which burn tiny holes in a specially treated heat-sensitive paper.

3. The records (TKG's) obtained can be analyzed for (a) frequency of contractions, (b) rhythmicity or regularity of contractions, (c) total relative work per unit period of time, (d) characteristics of contractions such as (1) intensity of contractions, (2) contraction time, (3) contraction duration and relaxation time, (4) contraction and relaxation rates, and (e) gradients of activity.

4. Because each pick-up records the force behind the change of radius of curvature under the brass rings, this three channel recorder allows a high degree of localization of effect. Hence the spread of the uterine contraction wave or its absence in certain parts of the uterus may be easily demonstrated.

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OXIMETER CONTROL OF ARTERIAL OXYGEN SATURATION IN ANOXEMIA STUDIES[1]

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INTRODUCTION

The most widely used clinical method of studying the effects of anoxemia on the electrocardiogram consists of giving the subject 10% oxygen inhalation for twenty minutes and taking records during this period (1a). This method of giving a gas with a constant oxygen concentration is the successor to a previous test in which the subject re-breathed room air to become anoxemic (2a). The re-breathing test was abandoned because it was found that the oxygen concentration of the inhaled gas at the end of the re-breathing period might vary from 13.5% to 6% (2b). The administration of 10% oxygen removed this important variation. This test has been used widely for the detection of coronary disease as determined by the electrocardiographic response and the patient's subjective reaction (1b–g).

Review of the literature reveals, however, that there is a marked physiological variation, as measured by arterial oxygen saturation, among different individuals breathing 10% oxygen and also in the same individual under different circumstances. A recent study of thirty-six normal young men breathing 10% oxygen under basal conditions showed a range of arterial oxygen saturation from 50 to 85% (3). In another instance in which the same gas was used to study coronary function on thirty-seven subjects, the range in arterial oxygen saturation was 52 to 87%, with one subject reaching the low level of 35%

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(1c). Houston recently demonstrated the marked variation of the arterial saturation in the same individual inhaling the same gas, depending on the subject's pattern of breathing (4). Using 10.5% oxygen, he showed a variation as great as 32% in arterial saturation (from 59% to 91%) in the same individual when respiratory minute volume was changed from 8.5 liters per minute to 18 liters per minute. With ordinary respiration this would be comparable to changing the oxygen concentration of the inhaled gas from 16% to less than 8% (3). Changes in the duration of time that a low oxygen gas is inhaled may also cause variations in the arterial oxygen saturation. Subjects placed in a decompression chamber at a simulated altitude of 18,000 feet (approximately equivalent to 10% oxygen at sea level) had an average arterial oxygen saturation of 77% at the end of ten minutes and 71% after fifteen to thirty minutes (5). In summary, then, the present method of using 10% oxygen inhalation for twenty minutes to induce anoxemia may produce an arterial oxygen saturation varying from 50% to 85% in different subjects and in the same subject.

Any procedure capable of producing the same constant level of anoxemia would therefore remove an important obstacle in the standardization and further use of the "anoxemia test" of cardiac function. The purpose of this study is to describe such a procedure. The method consists of giving the subject a mixture of oxygen and nitrogen that will produce a constant level of arterial oxygen saturation as measured by the Millikan automatically-compensated oximeter (6a, b). The oximeter is essentially a small bichromatic photoelectric colorimeter that is attached to the intact ear and measures continuously the arterial oxygen saturation. Its average accuracy, as determined by gas analysis of arterial blood, is (±) 3%. It has been used extensively in problems pertaining to aviation (7a, b, c, 5), and to clinical medicine (8a–g, 3, 4, 15, 16).

This preliminary report is concerned with observations on normal subjects at levels of 85%, 80% and 75% arterial oxygen saturation The lower level was set at 75% for the following reasons: (1) It is the approximate average arterial oxygen saturation resulting from 10% oxygen inhalation (1c, 3,5); (2) There is considerable cardiovascular stress at this point (3, 9); (3) It provides a safe margin before marked central nervous system symptoms appear (7b).

METHOD

Four normal young men inhaled mixtures of oxygen and nitrogen to induce the desired degree of anoxemia. Each subject was successively studied at levels of 85%, 80% and 75% arterial oxygen saturation on different days.

The oximeter was connected to an ordinary six volt storage battery. The apparatus used to administer low oxygen mixtures was a Heidbrink anesthesia machine (model 302A) in which were placed large tanks of pure oxygen and pure nitrogen. The inhalation tube of the machine was connected to an O.E.M. mask (model 720). The exhalation tube was disconnected so that the subject exhaled into room air. Electrocardiograms were taken with a Cambridge electrocardiograph.

The subject was allowed to rest by lying on the bed approximately one hour. During this time control blood pressure, pulse rate, respiratory rate and electrocardiogram (three limb leads and the precordial lead CF4) were taken. The oximeter was allowed to "warm up" at least 45 minutes with the earpiece on the standard filter and then on the subject's ear. When the "ear thickness" readings were constant, the "physiological setting" was obtained by giving the subject 100% oxygen.[2]

The side-arm of the inhalation valve was then attached to the gas machine and the actual test begun. The initial flow rate was approximately 10 liters nitrogen to 2 liters oxygen per minute. The oxygen flow rate or nitrogen flow rate, or both, were then constantly altered to produce the desired level of arterial saturation. Electrocardiograms were taken at the end of 10 and 20 minutes of anoxemia. Ear thickness readings on the oximeter were taken frequently as were blood pressure, pulse and respiration.

[2] After allowing the oximeter to warm up, the instrumental setting is obtained with the ear piece on the standard filter which simulates the human ear. The ear piece is then screwed to the subject's ear and ear thickness readings taken until constant, indicating maximal vasodilatation. The physiological setting is obtained by turning the "saturation" dial to some known value (98%, if the subject is breathing room air; 100%, if breathing oxygen, or to any other known value, as obtained by arterial blood gas analysis). Continuous readings of the arterial oxygen saturation can then be made. The ear thickness, instrumental setting and physiological settings at the end of an experiment, should check within a few scale units with those obtained at the beginning (6a).

At the end of this period the subject was given pure oxygen until his arterial blood was fully saturated and then allowed to breathe room air. Control electrocardiograms were again taken. At the conclusion of the test, the ear piece was replaced on the standard filter and the instrumental and physiological settings checked.

RESULTS AND OBSERVATIONS

No major difficulty was encountered in producing a given level of arterial saturation. An important factor in attaining this was a smooth induction of anoxemia. This could be accomplished if care was taken to induce anoxemia by decreasing the concentration of oxygen gradually so that the subject was not conscious of any change in inspired gas from room air. To do this, it was found that approximately two minutes were necessary to reach a level of 85% arterial saturation and 3–4 minutes a level of 80% or 75%. It was also found that it was not difficult to maintain a particular level, once reached. It was necessary, however, to make frequent fine adjustments in the nitrogen flow rate throughout the 20 minute period of anoxemia to keep the arterial oxygen saturation within 1 or 2% of the desired level. Occasionally, there were rapid swings in the arterial saturation as great as 5% above or below the desired level. These rapid swings corrected themselves spontaneously within a few seconds without changes in flow rates of oxygen or nitrogen and usually were due to minor disturbances in the room, such as talking or opening of a door.

The ability to produce and maintain any level of arterial oxygen saturation accurately depended more on the subject's being at ease than on any other factor. In one subject (not listed in Table I), who was quite apprehensive, the arterial saturation varied widely from 75% to 90% within a few seconds when 85% was the desired level. The ability to administer the gas mixture with proper dexterity was no great problem and was mastered in one or two trials.

The electrocardiograms were studied for any abnormalities, especially as to changes in the RS-T segments and T waves (Table I). In each of the four subjects studied at the three levels of anoxemia, 85%, 80% and 75%, no striking differences were observed between the various levels. Also, there were no marked differences noted between the electrocardiograms taken after 10 and 20 minutes of anoxemia. In no

TABLE I

SUBJECT	ANOXEMIA		B.P.	ELECTROCARDIOGRAPHIC CHANGES (IN MM., 10 MM. = 1 MV)							OXIMETER READING (SCALE UNITS)		
	Art. ox. sat.	Duration		Rate per minute	RS-T deviation		T wave changes				Ear thickness	Physiological setting	Instrumental setting
					I	I–IVF	I	II	III	IVF			
	%	min.	mm. Hg										
F. J.	85	0	132/68	63							75	100	100
		10	144/70	100	0	1½	−1½	−2	−½	−1½			
		20	132/70	81	0	1½	−2	−2	−½	−2	75	100	99
	80	0	126/66	83							74½	100	100
		10	132/64	94	0	1	−1	−1	−½	−2½			
		20	132/68	86	0	1	−1	−½	−½	−2	73	97½	97½
	75	0	124/62	79							72½	100	100
		10	148/70	97	0	2	−1	−1½	0	−1½			
		20	134/64	97	0	1	−1	−1	0	0	71	98	98½
N. S.	85	0	108/72	63							75	100	100
		10	112/68	79	0	½	0	−½	0	+1½			
		20	114/78	79	0	½	0	0	0	+2	74	99	100
	80	0	104/74	81							75	100	100
		10	112/72	100	½	½	0	+½	−½	+1			
		20	120/72	100	½	½	0	−½	−½	+2	75	100	99
	75	0	108/62	65							74½	100	100
		10	112/70	88	½	½	−½	0	0	+½			
		20	108/66	76	0	0	−1	+½	0	+½	73	100	97½
M. M.	85	0	124/72	79							76	100	100
		10	140/64	100	½	1	−1	−½	0	−1½			
		20	140/70	103	½	1	−1	−½	0	−2	75	100	99
	80	0	112/68	86							78	100	100
		10	130/72	100	½	1½	−2	−3	+1	−2			
		20	130/68	100	½	1½	−1½	−3	+1	−1	77	101	
	75	0	116/68	75							76	100	100
		10	140/70	100	0	1½	−1	−2	−1	−2½			
		20		100	0	1½	−½	−2	−½	−2½	75	102	99
T. S.	85	0	112/68	73							70	100	100
		10	114/62	81	0	1	+½	−½	−½	−1½			
		20	118/62	71	0	0	0	0	−½	−1	70	99	99½
	80	0	112/64	75							70	100	100
		10	118/70	94	½	2	−1½	−1½	−1½	−1½			
		20	120/64	83	0	1	−½	−2	−1½	−1	68	99	99
	75	0	112/66	68							70	100	100
		10	130/72	88	0	1	−1½	0	0	−1	70	99	98

instance was a positive test for coronary disease, as laid down by Patterson, Clark and Levy (1d) obtained. No abnormalities in rhythm or conduction were observed.

The oximeter was found to give the same degree of stability at the different levels (Table I). The final "ear thickness", "instrumental setting" and "physiological setting" did not vary more than 1–2 scale units from the initial readings. It can be said, therefore, that vasomotor changes due to anoxemia (10), and their effect on the ear thickness do not alter the stability of the oximeter in the range of 75–100% arterial saturation.

There was no pain or discomfort experienced from the ear piece. None of the subjects had symptoms at 85% or 80% arterial saturation. At 75% saturation, however, one subject (M. M.) complained of acute frontal headache after 10 minutes and another subject (T. S.) started sweating profusely after 10 minutes anoxemia. Both were promptly relieved when brought up to 80% arterial saturation. No changes in blood pressure, pulse (Table I), or respiration, necessitating termination of a test period, were enountered.

DISCUSSION

The importance of controlling the exact degree of anoxemia in any "anoxemia test" is apparent. The difference in cardiovascular stress at different levels of anoxemia has been demonstrated in normal human beings (3, 7a, c) and animals (11). It is especially important to be able to control the degree of anoxemia in looking for evidence of coronary disease. Variations in arterial saturations in current anoxemia tests may well account for frequent reactions (1a, e, f), "false positives" in normals (1g, 12), and high percentage (approximately 30–50%) of negative tests in persons with presumptive coronary disease (1d, e, f). The possibility of producing an arterial oxygen saturation as low as 50% in a subject with coronary disease, a situation quite possible with 10% oxygen inhalation, may be prevented as the arterial saturation is known instantly at all times during the test.

The method can be applied in anoxemia studies of coronary function under other physiological situations, such as during the administration of carbon dioxide (1c) or drugs (13). It can also be used in studying the effect of different degrees and duration of anoxemia on

other physiological phenomena such as the capillary fragility (8f), or electroencephalographic brain waves (14).

SUMMARY

A procedure for studying the effect of anoxemia on the electrocardiogram has been outlined and its practicability and consistency discussed. Its principle is based on the fact that by continuous fine adjustment of the oxygen concentration in a gas mixture a constant degree of anoxemia, as measured by the oximeter, may be induced in the same and different individuals. It is believed that this method is considerably more accurate than the currently used "induced anoxemia test" in which the subject inhales a gas with fixed oxygen concentration (10%).[3]

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SCOTTISH EXPERIMENTS IN SOCIAL MEDICINE[1]

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With each advance in knowledge and experience, the horizon of the art and science of medicine is ever widening. The outlook is no longer limited to the sick-bed or consulting room but ranges over the social, economic, and industrial life of a nation and beyond into the wider expanse of international health problems. More and more it is evident that medical care and the promotion of health in modern civilisation are closely knit with social and economic factors of profound concern to the individual, the family, and the community. The scope of public health has expanded through the impact of the social environment to give rise to the conception of social medicine as a scientific subject which affords a common meeting ground for "preventive" medicine and "curative" medicine—terms which no longer can be definitive of seemingly separate branches of medical practice. War, with its imperative demands on manpower and production, brought home acutely the social and industrial implications of health and sickness. In peace, no less than in war, the relationship between health and working efficiency is of intimate importance to the individual and of prime significance to the national welfare. No nation today can afford to neglect the development of health measures designed to prevent or minimise incapacity resulting from illness or injury.

In the Department of Health for Scotland we have been engaged in several studies and experiments in some difficult and hitherto little-explored fields of social medicine which have opened up several practical questions and point the way to further investigation. Prior to the war, our National Health Insurance Medical Service furnished a vast amount of information capable, after statistical analysis, of giving a measure of the extent to which ill-health and injury rendered people between ages 15–65 years unfit for remunerative employment. The

[1] A De Lamar Lecture delivered at the Johns Hopkins University School of Hygiene and Public Health, October 28, 1947.

amount of incapacitating sickness disclosed became a matter of real concern and a challenge to all concerned with the public health. From 1930 until the outbreak of war, the Department of Health for Scotland published yearly morbidity statistics relating to insured persons. Data were available to show age, sex, occupation, duration of incapacity, and the presumptive diagnosis. Unfortunately, these annual statistics became an early casualty of war when the staff became preoccupied in more serious affairs.

I. A STATISTICAL STUDY OF SICKNESS

For the year ending 30th June, 1938, (the last period for which details are available), the insured population numbered 1.8 million (37 per cent. of the total population). Incapacitating sickness lasting more than three days accounted for the loss of 25.9 million working days. Fresh cases of incapacity arising during the year numbered 417,000. Excluding 44,000 cases of influenza (a disease which can profoundly affect sickness rates), the number of new incapacities was 373,000, or 203 per thousand of the insured population. In addition, there were 31,000 persons unfit for work continuously throughout the whole year, representing 11.3 million lost working days (or 44 per cent. of the total lost time). Many of these patients were no longer suitable for economic employment, and the ailments chiefly responsible were mental and nervous disease, rheumatism, and disease of the cardiovascular and respiratory systems. In a country of about five million inhabitants these figures are of serious import. The returns for eight successive years brought the medical problem gradually into perspective. As might have been expected, sickness rates and duration of incapacity increase with age in men and single women; the rates for married women are dominated by conditions associated with childbirth. What had not been appreciated hitherto was the amount of long-continued or "chronic" incapacity and the fact that between one-fifth and one fourth of chronic cases were under 35 years of age.

With a broad measure of the problem to hand, further analysis was called for as a preliminary to determining what was necessary to minimise the amount of long-continued sickness. From 1937–39 clinical data were obtained for over 50,000 patients in a review of all cases where incapacity lasted for three months or longer. The sample was selective as regards population and sex, and as regards the type of ill-

ness. Obviously fatal diseases were largely excluded from the analysis and, therefore, conditions such as cerebral haemorrhage and malignant disease appeared less frequently than they would in general statistics of morbidity.

Of the first 7,000 patients specially investigated, approximately 53 per cent. were given a prognosis of early recovery; 22 per cent. were liable to recurring incapacity; in 10 per cent. the incapacity would be prolonged but with reasonable prospect of return to some form of employment; 15 per cent. (about 1 in 7) would not likely work again. A sample of 1,000 cases was analysed in some detail. Of these, at the time of examination, 85 per cent. were clearly unfit; about 4 per cent. were able for selected alternative employment. Of the unfit, 45 per cent. were under forty years of age, many of whom were liable to drift into a state of chronic incapacity; 10 per cent. were permanently disabled (1 in 9 of these were under forty years); in a further 11 per cent. the prognosis was doubtful with, at the best, an expectation of only limited or intermittent employment.

Two-thirds of the sample had received hospital treatment either as in-patients or as out-patients. The general medical practitioners reported that lack of facilities hampered diagnosis or treatment in 124 of the 1,000 cases, the chief obstacles being difficulty or delay in admission to hospital or in securing psychological investigation and treatment. Specialist advice was considered necessary and obtained by the Regional Medical Officer of the Department of Health in 89 cases. A new line of approach in treatment was recommended for 350 patients, including hospital admission in 48, psychotherapy in 47, change of work in 29, and return to work for psychological reasons in 16. The final diagnosis of the clinical condition responsible for prolonged incapacity showed that in the sample approximately 1 in 7 were disabled by rheumatism, 1 in 8 by cardiovascular disease (excluding cerebral haemorrhage), 1 in 8 by respiratory disease, and 1 in 10 by peptic ulcer or other digestive disease. Disablement through injury only accounted for less than 8 per cent., fewer than the proportion due to frank psychoneurosis. The cases classified as psychoneurosis did not by any means exhaust the number in which there was a psychoneurotic element. One feature worthy of notice was the tendency in some patients for a sequence of illnesses such as lumbago—influenza—duodenal ulcer.

This preliminary study of the immediate pre-war period, so very

briefly outlined here, furnished objective lessons which led to further experiments during the war, and which serve to direct and guide the post-war development of health measures. In the forefront is the importance of the volume of sickness among the working population and particularly at ages under forty years. Secondly, if we are to minimise the effects of sickness, and if we hope to conserve the working capacity of our wage-earners, the full resources of medical and surgical technique must be brought to bear upon our patients at an early and not at a late stage in illness. Thirdly, where early recovery is not forthcoming, a periodic review of diagnosis and treatment is called for, with close and sufficient cooperation between the personal physician and the specialist services. These formal deductions apart, however, there remains a challenge and a stimulus to a more intensive study of the natural history of disease—not merely its gross pathology but also the early and remediable stages of its evolution, the factors which predispose to it, and the circumstances which initiate it. In the field of industrial accident and injury, some headway has been made in the prevention of mishap and in the recognition of those termed the "accident-prone." The psychiatrists are adding to the understanding of the psychological factors which produce or complicate ill-health. Little or nothing, however, is known about the conditions which make for susceptibility to cardiovascular "accident," to respiratory "mishap" or to the "misfortune" of rheumatism. With some precise knowledge of this kind, preventive medicine would truly add to its stature.

II. AN EXPERIMENT IN PREVENTIVE MEDICINE

A further stage in the study of fitness for work was begun early in 1942 in an attempt to minimise breakdown in the health of war-workers. During World War I investigations into industrial accidents and fatigue showed that excessive hours of work lead to lower output and production, with increase in the rates of accident and general sickness. These lessons were seemingly forgotten in the early phase of World War II, although adverse conditions were intensified and increased by the weighty stresses of aerial warfare. As the all-out day-and-night production drive developed and the tension of total war enveloped the civilian population, the prevention of breakdown among essential workers, especially those of younger ages, assumed a new

importance. Young war-workers, and, later, older adults on essential work, whose general health gave cause for concern to their family physician, were given special clinical examination and, where necessary, patients were admitted to war-emergency base hospitals for detailed investigation and to country mansions, functioning as auxiliary hospitals, for intensive convalescence. Within 1½ years some 5,000 patients were dealt with.

Originally those patients were selected who showed symptoms of debility or fatigue, symptoms common alike to physical and mental stress or to early organic disease presenting few diagnostic clinical signs. Later the scheme was extended to include (i) debility after illness where hospital treatment or proper convalescence would expedite recovery of fitness, and (ii) conditions such as dyspepsia, anxiety states, asthma, etc., which are liable to recurrence where stress and strain as etiological factors remain undetected. After a minute clinical survey an assessment was made of etiological and predisposing factors, the immediate nature of the disability, the likelihood of recurrence, and the further measures required.

Of a series of 1,160 patients—23 required routine surgical or medical treatment in ordinary civilian hospitals; 29 had tuberculosis; 79 required change in type or place of occupation; 164 were able to resume their usual employment after advice and re-assurance; 169 were admitted directly to convalescent hospitals; 563 required base hospital investigation.

An outstanding feature was the small proportion of established organic disease. Surprisingly few early organic lesions were missed by ordinary clinical routine methods and required highly specialised hospital investigation. The overwhelming proportion of patients showed vague ill-health, with some degree of debility and often with an anxiety state, due to excessive hours of work, excessive travelling to and from work, and an unsatisfactory dietary. Too often those suffering from physical and mental fatigue carried on to an actual breakdown with, as a result, an unduly prolonged period of incapacity. The great majority responded rapidly to a brief period of rest and change under medical supervision. Recovery was often expedited because the complete medical overhaul made it possible to remove suppressed fears of serious disease. The results indicated that an adequate amount of

rest and recreation is essential to prevent and to combat the fatigue syndrome which, if undetected and untreated, can be the prelude to substantial physical and mental illness. The wise use of leisure as a prophylactic and therapeutic measure of high potency is a subject which deserves a high place in the programme of health education. Our experience also demonstrated (i) the value of careful investigation of the premonitory symptoms and effect of undue fatigue and early debility, and (ii) the need for adequate provision of convalescent hospitals for the management of early departures from health and, indirectly, in relieving the pressure on major hospitals.

III. AN EFFORT TO REDUCE INCAPACITATING SICKNESS BY REHABILITATION

We now had practical experience in reducing health-breakdown to a minimum and preventing the drift into chronic invalidism by prompt and effective treatment. In ordered sequence came the problem of what could be done to restore the sick and injured to the maximum attainable of health, working capacity and social independence. From the early days of the war the Services, particularly the R.A.F., had brought rehabilitation of their casualties to a high degree of efficiency—rediscovering another lesson of World War I which had largely been forgotten or discarded. On the civilian side there had been several orthopaedic out-patient clinics dealing with injured coal-miners, but there was no residential rehabilitation center in Scotland until in January, 1943, the Department of Health for Scotland transferred the large hotel at Gleneagles, Perthshire, from a war-emergency base hospital into a Fitness Centre for disabled miners. Workers other than miners were also admitted later, and in 1947 the unit was transferred to a self-contained wing of another general hospital side by side with a major orthopaedic unit, both units being served by the same orthopaedic team.

We recognised that judicious active rehabilitation would reduce the degree and duration of disability, and that medical responsibility does not end with primary medical or surgical treatment which deals only with a disease process or local injury. The work of the surgeon or physician cannot be considered complete until the patient has attained

the greatest measure possible of physical and mental fitness and has been restored to suitable active usefulness in society.

The ultimate material target of the scheme was the return of men to active employment. It was tempting to limit admission to those patients whose age and disability gave reasonable expectation of a successful issue. This policy, however, would have deprived an important pilot experiment of that harvest of knowledge and experience which is reaped from failure and disappointment. In the early stages, therefore, some patients, medical as well as surgical, were admitted whose prospects were distinctly unfavourable. A wealth of experience soon accumulated from which emerged certain definite principles for the selection of cases and for therapeutic technique. Age was found to be no barrier. Medical cases, no less than the more spectacular surgical cases, can respond to active rehabilitation provided there is no toxaemia or other definite clinical contra-indication.

The programme of treatment was designed not only to restore maximum physical function but also to promote and maintain the patient's will to recover. The patient has to be made to appreciate that while a great deal could be done to him and for him, there is much which he has to do for himself—a principle too often ignored in the past by the medical profession in their management of patients. The keynote, therefore, is activity by the patient, prescribed and controlled by the physician. Passive therapy, such as massage, radiant heat, and manipulation have their uses in the early stages but should merely be means towards the end of active movement, exercise, and recreation. The patient's day from 9.30 a.m. till 4.15 p.m. is fully occupied with the tasks of achieving fitness according to a time table carefully graded on a sound physiological basis. Observing the principle of continuity of supervision and treatment, the surgeon or physician in charge of the patient makes a frequent periodic review of progress, and ultimately a final assessment of fitness for work is made. The assessment of discharge is checked by a follow-up at 2 months and 6 months after the patient has left the hospital. The average stay in the unit ranges approximately from 50 to 80 days.

The results have been encouraging; the clinical assessments, as judged by the 6 months' follow-up reports, have been extremely accu-

rate. Of 1,900 miners and 270 others the results up to June, 1947, have been:—

	MINERS	OTHERS
Fit for former work	63%	69%
Fit for light work	19%	13%
Fit for alternative employment	5%	6%
Unfit at the end of course	1%	less than 1%

The remainder consisted chiefly of patients returned to the general hospitals for further primary treatment.

These figures are not statistically comparable with those of the fighting Services. Service casualties were of an optimum age group and usually were in first class condition before injury. The results I have quoted refer to a group of civilians of varying ages up to 70, many of whom had long been in indifferent health.

We have learned that rehabilitation methods cannot cover deficiencies in primary surgical or medical treatment, nor can they be applied *en masse* to patients as a mere supplement to primary treatment. To be of full value, accessory physical and psychological methods must be used at the appropriate moment during and after treatment; sometimes they should begin on the first day in hospital, and sometimes (e.g. prior to meniscectomy) even before operation.

We have learned further that "the patient must be fit if he is to have a job, but, equally, the patient must have a job if he is to remain fit." It has been aptly said that "the final stage in rehabilitation is re-employment, and remunerative work is often the best form of rehabilitation. . . . Much of the time and skill expended on medical care may be in vain if the patient is left indefinitely without work or in employment of a grade lower or higher than that of which he is capable." The physician or surgeon has a responsibility, which cannot be delegated, in determining when his patient is fit for work and for what kind of work he is fit. The medical profession must, therefore, have some appreciation not merely of clinical science but of the conditions under which his patients live and work. There is need for a closer link between the medical services, the social services, and industry if our professional labours are to achieve their time end.

IV. A STATISTICAL INVESTIGATION INTO SOCIAL CONDITIONS

Sociological research is now receiving more attention than hitherto, but we are still woefully deficient in precise knowledge of the influence of social conditions on the health and welfare of the peoples of the world. To build the new world of happiness and prosperity upon the old, we need to study the effect which the changes over the past century have had on the life of the people and ascertain how the people react to conditions of life at the present day.

In Scotland, at the end of the 18th century, and again in the middle of the 19th century, two statistical accounts were made. Sir John Sinclair, who took the first account in the latter years of the 18th century, introduced the phrase into the English language and his interpretation was "an account of the state of the people." These two investigations contain a mass of material about the conditions of life in Scotland 150 and 100 years ago, with information about local customs, local occupations, and local way of life. One of the 160 questions which Sinclair asked related to the most prevalent distempers and their cause. The answers given to this question shed an interesting light on the diseases prevalent in Scotland at the beginning of the last century, their distribution and their relation to local climatic conditions.

Recently, it has been decided to undertake a third statistical account in Scotland and preliminary steps have already been taken in surveying four areas of the country, each under the supervision of a Scottish University. The unit of study is the parish and the following seven headings form the basis of individual accounts:—

1. Physical basis.
2. History of local community.
3. Population.
4. Public and social services.
5. Housing.
6. Agriculture, industries, and commerce.
7. Way of life.

These headings reflect a wide comprehensive undertaking in surveying the whole of the country. The project has been summed up in these words—"The main task will be to describe not merely the physical facts, the public and social services, and the industries of the area, but

to show how, in that environment and with those material conditions, the people live. We shall want to know not only about houses, but about family life; not only about churches, but about what religion means to the people; not only about industries and products, but about the attitude of the people to work and leisure. We shall want to know of any significant changes that have occurred in customs, feelings and attitudes. And we shall want to know their hopes and prospects for the future."

V. MEDICAL CARE IN A LARGE RURAL AREA

Since 1915, there has been, in Scotland, a medical service for the Highlands and Islands which has aroused wide interest and has attracted visitors from many parts to see it in operation. The origin of the Highlands and Islands Medical Service was fundamentally a question of the economics of medical care—a question which today has assumed new importance throughout the civilised world. The problem then, as now, was to apply a remedy without disruption of the established principles of medical practice. Let me give you a brief picture of how in Scotland a State-aided medical service was evolved and developed.

The Highlands and Islands include almost one half of the land surface of Scotland, lying to the North and West, inhabited by some 300,000 people (representing only one-sixteenth or less of the country's population). The region is famed for mountain, glen, moor and seaboard, of unusual beauty and grandeur. Judged by American standards, the scales for distance and population are small, but measured in terms of geographical configuration and of physical exertion and hazard, the provision of medical care in the more remote areas entails effort and endurance of the highest grade. Depopulation over a century has taken its toll of a vigorous and sturdy race; those who remain toil hard to wrest a living from a relatively infertile soil and from stormy seas. Communications even in these days are difficult and journeys are often circuitous and tedious. In the islands there are no railways, and on the mainland the nearest railway station may be several hours distant by automobile. Some of the older inhabitants still living have never seen a railway train.

In 1912 the British Parliament appointed a Committee to examine

the adequacy of the medical services then existing in the region, and to advise "as to the best method of securing a satisfactory medical service therein." The Committee toured the area and obtained first-hand evidence from over 250 witnesses, representing all classes of the community (including over 90 doctors, many of whom had spent a lifetime in the remote areas). Having ascertained the facts and surveyed the problem, the Committee reported that the combination of social, economic, and geographical difficulties in the Highlands and Islands demanded exceptional treatment. The sparseness of population in some parts, the configuration of the country, the climatic conditions, and the straitened circumstances of the people made the medical service uncertain for the people,—onerous and, at times, hazardous for the doctor. In general, medical care was inadequate. The remedy was equally forthright. Medical care and public health services could be developed and correlated provided a suitable grant could be forthcoming from national funds. If doctors could be guaranteed a reasonable minimum income, with adequate nursing and hospital services, well-trained practitioners would be attracted to the Highlands and Islands to combine with a family doctor service such public health duties as would be found useful and expedient. Within eight months Parliament passed legislation establishing the Highlands and Islands Medical Service Fund "for improving medical services, including nursing, in the Highlands and Islands of Scotland, and otherwise providing and improving means for the prevention, treatment and alleviation of illness and suffering therein." Under the Act, schemes were approved covering grants to (i) doctors, (ii) nursing services, (iii) specialist, hospital, and ambulance services, (iv) telegraph and telephone services.

World War I was in progress, however, and although a beginning was made at once, the scheme only got into its stride when hostilities ceased. The results exceeded all expectation. Within a few short years the people of the Highlands and Islands were receiving medical care which became the envy of many in the more prosperous South.

The principles governing the administration of the service have been based upon two primary economic objectives, viz., (i) every person in need of medical attention should be able to secure the services of a fully qualified doctor; (ii) each doctor in the scheme should be assured of a definite minimum nett income.

The few patients able to do so pay the doctor on a fee basis comparable to that obtaining in ordinary private practice. Medical care for those in receipt of public relief is paid for on a block grant basis by the local authority responsible for poor relief. Employed persons contributing to the National Health Insurance scheme are covered by the statutory capitation fee payable for medical benefit. There remain families of the crofter or cottar class, and families of insured workers to whom ordinary medical fees would be an undue burden. For these a schedule of modified fees is laid down which must not be exceeded whatever the distance of the patient from the doctor's residence. Every doctor within the scheme undertakes to observe the underlying principle of the fee schedule.

You will note that as regards private patients and those treated under the statutory services, the Highlands and Islands doctor is exactly in the same position as his brethren elsewhere. The major part of his work, however, is concerned with the families of the crofter-cottar class commonly referred to as "scheme patients." Even were the doctor to receive the maximum fees agreed upon, he would still be far from securing a proper living income. In actual fact, where he applies the *spirit* of his agreement in preference to a strict adherence to the permitted maxima, the doctor invariably adjusts his charges to suit the economic circumstances of his patients—circumstances of which he is uniquely aware by virtue of his position as family friend and adviser, as well as family physician. To supplement his income as compensation for reduced earnings and to offset legitimate professional overheads, each doctor receives a yearly grant from the Highlands and Islands Medical Service Fund. Each individual grant can be varied from time to time according to fluctuations in the circumstances of the individual practice. This year (1947) the target is to provide each doctor with a minimum yearly nett income of £800 after professional overheads have been met. Financial aid has also been forthcoming to provide (i) suitable houses for doctors, (ii) facilities for holiday leave and post-graduate courses at the various medical schools, and (iii) special assistance in the event of serious illness or other emergency.

These arrangements do not make the doctor a salaried servant of the State. In the exercise of his professional duties they leave him as independent and unfettered as his brethren in general practice elsewhere. The contribution of the State is primarily to relieve him from

undue economic burdens and to give him encouragement and scope to practise his profession.

Before the advent of the Highlands and Islands Medical Service, nursing facilities in the Highlands and Islands were haphazard and wholly inadequate. Under the scheme a most efficient nursing service has been rapidly developed. County and district nursing associations were organised and integrated to provide district nurses stationed at strategic points where they could best contribute to medical care. Almost all of these nurses—colloquially and affectionately called "Queen's Nurses"—are fully qualified in general nursing and obstetrics and, in addition, have had special training for domiciliary work under the auspices of the Queen Victoria Jubilee Institute of District Nursing. The nurses are appointed by the local nursing association but they work directly under and with the local medical practitioners. Words cannot pay adequate tribute to the professional competence and devotion to duty of our nurses in the Highlands and Islands.

Although the nursing service is based upon domiciliary care (including obstetrics and infant welfare), the nurses are actively engaged in the work of the School Medical Service, and in such matters as hygiene and dietetics they bring practical advice to the homes of the people. Their close contact with both doctors and people give them unusual opportunities for the early detection of illness and in effect they function as an efficient health intelligence service.

The local nursing associations are financed by local subscriptions plus grants from the local health authorities supplemented by considerable sums from the Highlands and Islands Medical Service Fund. The financial assistance given has considerably increased the number of nurses employed and ensures that each nurse has a reasonable salary, a suitable residence, means of transport (usually a small car) and a telephone service.

The practical unit in the Highlands and Islands Medical Service is a doctor with one or more fully trained nurses, a closely-knit team designed to bring domiciliary medical care to every individual within a given area. I would draw particular attention, however, to the fact that the doctors and nurses are brought directly into the field of public health. In the isolated areas the doctor enters the service through appointment as a parish Medical Officer for statutory services under the County Medical Officer of Health. He is, therefore, avail-

able to the Medical Officer of Health for immediate action in the locality and he has behind him the Medical Officer of Health for help and guidance in such matters as infectious disease, water supplies, sanitation and emergencies of all kinds. The relationships between Medical Officers of Health and the general medical practitioners is one of cordial friendship and mutual confidence. With the functions of school nurse, health visitor, and social worker centred on the district nurses, and the general practitioners undertaking the duties assigned to them by the Medical Officer of Health, the Highlands and Islands Medical Service has demonstrated how the family medical service and the preventive health service can be integrated to the benefit of the community.

Behind the general practitioner we have placed the resources of a hospital and specialist service. Up to the end of World War I, the existing hospitals were inadequate in accommodation, equipment and personnel, with little possibility of improvement on a satisfactory scale without considerable financial assistance. For obvious reasons first priority was given to a surgical service. This involved the appointment of full-time surgeon-consultants to key hospitals on the Islands and on the mainland, substantial modernisation of layout and equipment, and a considerable increase in nursing staff. Here again the Highlands and Islands Medical Service Fund provided the necessary finance. Substantial grants were made towards the salaries of surgeons and hospital personnel, and towards capital and maintenance expenditure for buildings and equipment.

With its immediate and somewhat spectacular blessings, the surgical service could not fail to stimulate public demand for further extension of specialist services in other fields. Inverness, the capital of the Highlands, was clearly the centre for major development. At Inverness Royal Infirmary, an E.N.T. specialist was established in 1929, and a conslulting physician in 1938; in the years between these two appointments suitable grants made possible up-to-date radiological and laboratory facilities. The impact of war in 1939 quickened the tempo of expansion and development. On the outskirts of Inverness, the Department of Health for Scotland built a major base hospital staffed and equipped for major surgery, medicine, orthopaedics, E.N.T., dermatology, gynaecology, and jaw injuries, with a full range of radiological, laboratory, pharmaceutical and physiotherapy facilities. Operationally the War Emergency Hospital was closely linked

with the voluntary hospital, the resources of both institutions being freely interchangeable. To the specialist teams there came two obstetrician-gynaecologists, an orthopaedic surgeon, and a second consulting physician. Ophthalmic and dental services are as yet undeveloped except through the School Medical Service, but the deficiency will be remedied in the forthcoming National Health Service.

The specialists do most of their work in the hospitals to which they are attached. The general practitioners, however, are able to arrange for a specialist consultation at the home of a patient or at some convenient centre such as the house of the local doctor or district nurse.

This brings me to a problem inherent in a medical service in remote areas, viz., communication and transport. Let me illustrate briefly. The configuration of the country, climatic conditions and the inadequacy or, in some parts, the non-existence of roads or paths, often make a trip of some 10–20 miles an arduous or even hazardous undertaking. To reach a patient separated from the nearest road by a few miles of treacherous sea, a doctor or nurse may wait for hours—in winter storms, for days—before the only available craft dare venture on the water. The return journey may have to wait until storm and flood abate. The daily round or a midnight emergency may mean a lonely trip by automobile, boat, pony and a final scramble on foot along a cliff or across a bog. Professional life under these conditions breeds a race of doctor and nurse famed for zeal and daring, wise forethought, incredible patience and marvellous ingenuity!

Some historian may one day record that the automobile above all else revolutionised medical care in the Highlands and Islands. Grants to doctors take into account the condition imposed under the scheme that each practitioner shall provide himself with suitable means of transport. In most areas ambulance services have been provided for the transport of patients to and from hospital, with, in recent years, an increasing use of the air-ambulance. With the cooperation of the Scottish civil aviation authorities, it is now a commonplace event in an acute emergency for a patient in the remote Outer Hebrides to be picked up on the sandy shore by plane, flown South and to be on the operating table in a University hospital within 3–4 hours—a journey which normally would take at least 2 days by mail-boat and rail. The potentialities of the air-ambulance give great promise

for the future, and we await with great interest and expectation the development of the helicopter air-ambulance which promises a solution of a difficult problem facing us in lonely islands and mountainous glens.

The aim of the Highlands and Islands Medical Service has been the provision of medical care within the economic means of all sections of the community, based upon the family doctor with the essential complementary services of nurses, specialists and hospitals. The State contribution has been, first, the necessary finance and, second, a flexible central administration under the Secretary of State for Scotland through the Department of Health for Scotland. The central administration has always been designed to be constructive and not restrictive, intimate and friendly rather than cold and impersonal. Our policy has established and maintained the cooperation and goodwill of all concerned—doctors, local authorities, voluntary agencies, and the general public. Since the conditions in the Highlands and Islands vary so much from place to place, a full appreciation of the particular difficulties of each individual practice is essential for the smooth day-to-day operation of the medical services and for the intelligent planning of expansion and development. Continuous personal professional contact has therefore been maintained between the central Department and the medical personnel in the field through one of the Department's headquarters' medical staff experienced in the problems of rural practice. On this whole-time medical officer devolves the whole range of medical questions arising in the Highlands and Islands area—general and specialist practice, hospitals, nursing, public health and other statutory services. From the outset, his systematic visits to each practice in the area made the medical and nursing personnel aware that an active and helpful interest was being taken in each individual and gave a welcome opportunity for discussion with a medical colleague to those with few opportunities for direct contact with current developments in medical practice and opinion. The best tribute to the administrative handling of the scheme has come recently from the doctors themselves. The Highlands and Islands practitioners, through their British Medical Association Committee, made a special plea to the Secretary of State that under the forthcoming National Health Service, they should continue to serve under the administrative aegis of the Department of Health for Scotland. They based their request upon the fact that

their relationship with the central Department over the past 30 years had been one of confidence and amity.

Standing on the threshold of the forthcoming National Health Service we acknowledge that much remains yet to be done. The people of the Highlands and Islands, however, have enjoyed a measure of medical care with an improved standard of health undreamed of 40 years ago. They are proud of their doctors and nurses, their specialists and their hospitals, and the doctor-patient relationship is the envy of our profession toiling in the cities. We have no difficulty in obtaining doctors, specialists or nurses for any area within the scheme; indeed, the numbers and calibre of applicants for vacancies are frequently embarrassing. The quality of the service is acknowledged to be high. With a satisfactory guaranteed nett income, improved transport facilities, access to specialists, and the means for post-graduate study, the typical Highlands and Islands practitioner is well above the average in professional acumen and knowledge.

I conclude this brief outline by quoting the judgment passed upon the Highlands and Islands Medical Service by one who saw "the former and the latter days"—the late Dr. Eneas MacKenzie of Tain, Rossshire, a sturdy independent Highlander who was a prince among doctors and a beloved physician to his people. "Considering the geographical character of our country, the Highlands and Islands of Scotland have a medical service unequalled for efficiency in any part of the world.... We have lost our sense of loneliness as access to colleagues, specialists and hospitals is easy. This has brought home to the medical practitioner what is the very foundation of his being able to give efficient help to his people, namely, a confidence in his own capacity to deal with any individual case and a knowledge of his own limitations.... It is fine to have been allowed to live and work and help into being what has been accomplished."

These, then, are some of the excursions into the wide field of social medicine which we are making in Scotland. They provide no world shattering discoveries but they represent simple efforts to achieve a higher standard of national health. That these endeavours have been possible is a tribute to the happy relationship which exists in our country between all those agencies working towards that objective. I hope they have been of interest to you.

ANTETHORACAL TRANSPLANTATION OF THE STOMACH IN THE TREATMENT OF CONGENITAL ATRESIA OF THE THORACIC ESOPHAGUS

A Preliminary Report

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The method of treatment of congenital atresia of the esophagus depends, of course, on the esophageal anomaly encountered. Atresia may result in a complete agenesis or absence of the esophagus, which is quite rare, or consist of a very small defect a centimeter or less in length. The surgical management of the different degrees of atresia requires various methods of construction of the continuity of the gastrointestinal tract. In the event the blind ends of the proximal and distal segments of the esophagus are sufficiently close together, one centimeter or less, primary end to end anastomosis of these segments with closure of the tracheo-esophageal fistula is the operation of choice. But in certain cases, particularly those in which no air is found in the stomach or intestine due to the absence of a tracheo-esophageal fistula or in those patients in which the atresia of the esophagus is so extensive as to make it impossible to bring the blind ends together, it is then incumbent upon the operating surgeon to employ other means to construct an artificial passage between the proximal and distal blind segment.

It is the purpose of this report to call attention to a method of construction of such an artificial passage which is, from a technical standpoint as well as ease and facility of performance, a most gratifying procedure, i.e., the antethoracal subcutaneous implantation of the stomach in infants a few days old in which the diagnosis of extensive atresia of the esophagus has been made. In two such patients complete mobilization of the stomach at the primary operation was accomplished, thus permitting the cardiac end to be brought up to the level of the clavicle followed by an esophago-gastrostomy in a one-stage operation.

Technique of Operation

Under very light drop ether anesthesia, after the usual preparation of the skin, a left subcostal incision 6 cm. in length was made and carried through the underlying fascia. The rectus muscle was divided and the peritoneal cavity opened. The left lobe of the liver was retracted. The stomach and intraperitoneal portion of the esophagus were identified. The atretic portion of the esophagus was divided together with the vagus nerves in the substance of the diaphragm. The left gastric vessels, including the vasa breva, were ligated and divided. Mobilization of the stomach was completed by dividing the gastrocolic and gastrohepatic omenta, preserving the right gastric and gastro-epiploic vessels. The stomach was withdrawn through the incision and because of the very small size of the infant thorax the cardiac end could be brought up above the clavicle without the slightest tension. An incision 2 cms. in length was made just above and parallel to the clavicle. Between the latter and the original subcostal incision a tunnel was made in the subcutaneous tissue by blunt dissection with a curved clamp. The stomach was then placed under the skin and subcutaneous tissue and drawn up through the tunnel and out through the incision just above the clavicle where the cardiac end was sutured into place. The intraperitoneal portion of the esophagus was brought out through a separate opening in the skin at a slightly lower level and medial to the incision above the clavicle. A tube was inserted in the esophageal opening in order to feed the infant immediately after the operation. This intraperitoneal esophagus was fixed to the adjacent skin with interrupted sutures. The blind end cervical segment of the esophagus was then brought up and into the neck through a separate incision made along the posterior border of the sternomastoid muscle and drawn down to the cardiac end of the stomach by tunnelling under the bridge of skin remaining between the incision above the clavicle and that which was made to mobilize the blind cervical stump. The atretic end was then incised and anastomosed to the cardiac end of the stomach with two layers of interrupted sutures. This anastomosis was then buried by suturing the skin over it.

The postoperative convalescence in both patients was remarkably uneventful except for some leakage of saliva at the point of anastomosis due to the formation of a small fistula. Feedings were made through the tube entering the stomach and even down into the duodenum by way of the opening in the distal esophageal stump.

The two patients were discharged from the hospital but survived only a year when both succumbed to infantile diarrhoea associated with terminal staphylococcus aureus haemoliticus infections beginning in the ears and followed by pyemia with multiple abscesses in the lungs and in one in the liver. The cause of the diarrhoea was not determined. Autopsy revealed that the transplanted stomach in both patients, which had functioned normally as far as the gastric motility and secretion were concerned, had formed a perfectly functioning tube and had remained viable. The small leak in the anastomosis was probably due to slight tension which could have been avoided.

One of the remarkable features was that the infants showed no signs of shock during or following operation probably due to the fact that the blood vessels going to the stomach at this age were so small there was no loss of blood and only an hour's operating time was consumed in each case. The ease of complete mobilization of th stomach in an infant up to ten days of age must be experienced to be fully appreciated.

Inspite of the fact that these two infants only survived a year following operation, it is felt that their deaths were due to factors which had nothing to do with the technical side of the operative procedures and that this method of transplantation of the stomach may prove to be a most useful surgical procedure in constructing a new passageway in the alimentary canal in cases of extensive atresia of the thoracic esophagus which do not lend themselves to a primary anastomosis between the two blind segments. The absence of surgical shock in these two cases was most striking and of interest because of the fact that a neurogenic element at this age of five and eight days would probably be lacking.

In his discussion of a paper on congenital atresia with tracheoesophageal fistula by Singleton and Knight (Trans. Southern Surgical Association, Vol. 55, 1943), Dr. Alfred Blalock of Baltimore, in referring to one of these cases, stated: "Some months ago Doctor Rienhoff had a similar case, and the procedure which was performed differed only in that the vessels at the upper end of the stomach were divided, and this allowed Doctor Rienhoff to place the upper part of the stomach beneath the skin of the anterior wall of the chest."

1. Attention is specifically directed to the fact that the above operative procedure was well borne by two infants five and eight days old which were in a very serious state of malnutrition and in whom there was evidence of a pneumonitis from regurgitation.

2. Although the procedure may sound formidable it may be carried out rapidly and without shock to the patient.

3. The operation of constructing an artificial alimentary canal may be completed in one stage, thus avoiding the multi-stage antethoracal esophagoplasties heretofore employed.

4. Extrathoracic subcutaneous implantation of the stomach avoids, in such poor operative risks, the hazards of intrathoracic procedures.

Brief Abstract of Cases

1) Baby boy Oren, referred by Dr. Schaefer. Mercy Hospital, History No. 49034. Age nine days. Date of birth November 13, 1941. Operated on November 22, 1941; Died November 6, 1942. Baby had normal spontaneous delivery November 13, 1941. Weight 5 pounds 7½ ounces. Did not take feeding well. Regurgitated. Spells of cyanosis. Congenital atresia of the esophagus. Blind pouch opposite the second thoracic vertebra. No gas in intestine in flat plate of abdomen. Patient progressed satisfactorily after operation until August 10, 1942 when he began to lose weight due to symptomatic diarrhea. Developed staphylococcus infection. Weight 9 pounds 6 ounces. Skin soft, velvety.

Physical examination October 12, 1942. Baby is an undernourished male child, apathetic and appears younger than his 10½ months of age. Color is good, no cyanosis or jaundice. There is a scar and small opening on second rib on left side. The bulging mass of stomach can be made out to the left on sternum in the opening below the skin. Several excoriated areas are present over the back and remnants of his previous staphylococcus infection. On October 12, 1942, baby's weight increased steadily for three days and child seemed to be doing very well. Following this the child again developed severe diarrhoea and succumbed November 6, 1942.

2) Baby girl Hart, referred by Dr. T. Terry Burger, Women's Hospital, History No. 22958, five days old, weight 5 pounds 8 ounces. Operation May 13, 1943. Convalescence uneventful. Discharged July 30, 1943. Weight 8 pounds 2 ounces. Fed through tube.

On March 19, 1944. Developed diarrhoea with red throat. Temperature 40. Otitis media. Positive staphylococcus aureus blood culture. Succumbed March 22, 1944, in Johns Hopkins Hospital. History No. H. L. H. A32481.

Personal communication from Dr. Willis J. Potts, Children's Memorial Hospital, Chicago. Infant with congenital atresia of esophagus operated on March 1st, 1948. "Without any difficulty I freed the stomach, brought it up under the skin of the chest and sutured it to the upper end of the esophagus in the neck. There was no shock or loss of blood. Condition good at end of operation. Child died following day, temperature 108°, supposedly an anesthesia death associated with edema of the brain. Circulation of stomach seemed perfect and anastomosis beautifully healed. I was surprised to find with what ease the stomach could be brought up to the collar bone."

PROCEEDINGS OF THE MEETING OF THE JOHNS HOPKINS MEDICAL SOCIETY

Held in Hurd Memorial Hall, January 12, 1948

The Use of Large Skin Flaps for Surface Repair. DR. MILTON EDGERTON. (*Department of Surgery, Johns Hopkins Hospital.*)

As a result of the challenge of World War II, new strides have been made in the use of large full-thickness flaps. The success in later surgery to tendons, bones, and nerves depends on effective preliminary surface restoration. The time-honored tube flap is now no longer the method of choice. Particular value has been shown in the use of large "direct" flaps. These may be raised from the abdomen, chest, or thigh, and placed into defects on the lower leg, hand, or arm at the original operation. They may be detached and inserted within a period of about three weeks or even less.

The obvious advantages of these flaps over the use of tubes lies in (1) the great reduction in hospitalization time, (2) the possibility of earlier definitive work on deep structures, and (3) in the actual conservation in flap tissue.

In both military and civilian life, one occasionally meets with a surface defect of such large proportions—particularly on the lower extremity—that the use of a cross-leg direct flap would not offer an adequate donor site. In these cases, the broad expanse of the abdominal and chest skin offers the most logical source of such a flap. It is not technically possible to apply the lower leg beneath such a direct flap. The use of a large tube would involve the loss of many months in transfer, the dangers of a narrow pedicle, and an irreducible waste of tissue from shrinkage.

I would like to mention our experiences here at Hopkins with a new method worked out at Valley Forge General Hospital during the war, under the supervision of Dr. Bradford Cannon. This employs the use of the so-called "jump flap". It is raised with a broad, short pedicle, like similar direct flaps. It differs in being attached first to the arm as a mobile vascular pedicle. The arm carries the flap to its recipient site, for example on the lower extremity. An opposing "mate flap" can be raised on the forearm, at the original operation, and used to cover the raw undersurface of the abdominal apron flap. Split grafts may then be applied to the abdominal wall donor site, and thus a closed wound is secured just as in the use of tubes. The flap is sewed onto the arm primarily with subcuticular sutures. Immobilization of the arm is easily obtained with adhesive strapping. Because of the broad pedicle and consequent good blood supply, the greatest dangers at this stage are from venous thrombosis, stasis, or kinking of the pedicle. A mechanics' waste dressing will combat these effectually.

Either one or two delays may be indicated at the second and third weeks, de-

pending on the size of the flap. It should be pointed out that flaps approaching one square foot in area may be transferred by this means.

Approximately five weeks following the original procedure, and under spinal anesthesia, the flap is then detached completely, the patient flexes at the hip and knee, and the flap may be applied to a defect located at any point on the lower extremity, over the sacrum, hip, or shoulder. It is important that all deep scar be excised and that minute blood supply be obtained. The flap must be placed into the area without tension, allowing approximately ten per cent for linear shrinkage.

Fixation may be obtained with subcuticular sutures of non-absorbable material, and a pressure dressing again applied. It is usually essential to utilize a plaster of paris splint to maintain the flexion of the patient.

At the seventh week, one-half of the attachment from the arm is severed, and after an additional week the arm is separated and its "mate" flap resutured into the forearm. At the same time, the flap is placed into the leg, and the procedure has been completed in seven to nine weeks.

We know of no other method whereby such a large block of tissue could be transferred in a comparable period of time and with comparable safety. I should like to show a few slides of a patient, D. Z., age 17, with traumatic encircling avulsion of the skin from the left lower leg—years of disability, including a draining eczema, and faulty development of the tibia followed. It was necessary for this boy to wear an absorbent dressing at all times. Treatment with a tube flap was first utilized, and after eight months succeeded in covering only a small fraction of the defect. In summary, the use of large full thickness flaps will, in many cases, allow non-union fractures to unite, will permit callus to thicken, and will make it possible to carry out tendon transfers and grafts, nerve sutures, and permit adequate covering for bone grafts. Such procedures, of necessity, require long months of hospitalization. Open direct flaps will give rapid surface repairs, in most instances, with a minimum of heart-breaking complications. Whenever an indirect flap is needed because of the distance of the defect from sufficient donor skin, we feel that the "jump flap" from the abdomen via the arm is the method of choice. It is most useful in thin, limber individuals of a young age group. It requires constant encouragement of the patient's morale. But, under these restrictions, it has proved a versatile and useful procedure, and, in fact, the only solution to a few difficult problems.

Discussion was postponed until all the papers were presented.

Observations on a Skin Homograft After Sixty Days of Pyribenzamine Therapy. DR. DALE G. FOSTER and DR. EDWARD M. HANRAHAN. (*Department of Surgery, Johns Hopkins Hospital.*)

Homografting (grafting skin from one person to another) is not permanently successful. There is considerable evidence that the reason for this is the develop-

ment in the host of an active systemic immunity to the antigenic foreign tissues of the homograft. Since histamine is frequently released in antigen-antibody reactions involving the skin, it was postulated that possibly histamine was released by antigen-antibody reaction between the homograft and the tissues of the host, and that the histamine so released might play a role in the destruction of the homograft. The authors thus were led to try the clinical effect of an anti-histamine drug, Pyribenzamine, on the survival of a homograft in one case.

A split-thickness graft from a white male was placed in a full thickness skin defect on a colored female. The host received Pyribenzamine therapy for 60 days, at which time the homograft was apparently viable. A biopsy at this time showed living skin with hair follicles and sweat glands, but it could not be determined whether the original graft had survived or whether it had been replaced by tissues from the host. At the end of 90 days the homograft had essentially the same appearance as at 60 days. No conclusions could be drawn from this isolated observation, but it was felt that further investigation was indicated.

Arterial Hemangiomas. DR. WILLIAM P. LONGMIRE, JR. (*Department of Surgery, Johns Hopkins Hospital.*)

In recent years, the term congenital arteriovenous aneurysm has been used for a variety of peripheral vascular lesions. Included in this group is a certain type of lesion which could better be known as arterial hemangioma. These lesions are characterized by (1) a pulsating compressible tumor, (2) enlarged afferent arteries, (3) a systolic thrill and bruit over the tumor, or the afferent arteries, or both, (4) enlarged efferent veins, (5) superficial capillary hemangioma, the so-called port wine stain, in the overlying or surrounding skin, (6) increased local skin temperature. They do not present the true clinical signs of an arteriovenous fistula. Seven such cases have been observed during the past two years. Treatment of these consists of complete local excision of the tumor when possible, or partial excision of the tumor and ligation of afferent arteries when total removal will produce disfiguring or disabling results.

The Treatment of Facial Paralysis. DR. EDWARD M. HANRAHAN. (*Department of Surgery, Johns Hopkins Hospital.*)

The use of fascia to ameliorate the effects of the loss of the seventh nerve is a generally accepted surgical procedure. There is, however, considerable disagreement regarding exactly how the fascial strips should be used to obtain the best result. The principal items of disagreement have to do with points of lateral fixation which might best bring about a balanced face and a certain amount of motion to compensate for the loss of motility in the paralyzed muscles. The best results were obtained by utilization of a combination of procedures which have been tried previously. It is important that the mid points of the lips be solidly immobilized against the pull of the unaffected side. No motion is desirable or necessary at these points which are anchored securely by fascial strips fixed to the temporal fascia. It is desirable, however, that motion be imparted to the line of

expression just lateral to the mouth, and to bring this about one fascial strip is fixed to that part of the temporal muscle which has the greatest excursion. This has given better results than fixation of that strip to other movable points, such as the masseter muscle. Photographs showing the result of this operation will be shown.

Plastic Surgery and Its Relation to Other Specialties. DR. JEROME P. WEBSTER. (*Department of Surgery, Presbyterian Hospital, New York, New York*).

It is difficult to define the field of plastic surgery as it borders on so many of the surgical specialties. A doctor obtaining superior results in the treatment of any type of disorder rapidly accumulates patients suffering from that condition. Therein lie the seeds of specialization. From early Egyptian times to the present, specialization in medicine existed, although usually practice was not limited to one small field. Tagliacozzi, anatomist and surgeon of Bologna (1545–1599), was noted for his rhinoplastic operations and wrote the first book on plastic surgery. When, over two centuries later, Joseph Constantine Carpue in 1816 revived the art of plastic surgery in Europe, certain general surgeons during the nineteenth century performed plastic operations as a part of their surgical practice. Pancoast, Warren, Buck, and Abbe, in this country, became noted for this type of surgery. John Staige Davis was the first to limit his practice to plastic surgery. Blair of St. Louis, originally an anatomist, devoted his time to this field, although he always considered himself a general surgeon.

Certainly a general surgical background is essential for the performance of plastic surgery operations to correct deformities in any part of the body. Halsted, realizing that better work would result if a surgeon's interest were concentrated in one special field, induced men like Cushing, Young, and Crowe, with general surgical backgrounds, to develop neurosurgery, genito-urinary surgery, and otolaryngology. In Halsted's clinic, free skin grafts were extensively used far earlier than in any other clinic in this country. However, he did not support Davis' contention that plastic surgery should be a specialty. His residents received training in a wide field, but the patients sometimes suffered when inexperienced residents, without supervision, operated upon an occasional hare-lip or cleft palate. Proficiency comes with a concentration of thought on the various aspects of any particular medical problem, and a wide experience in treating many cases largely similar in character.

World War I focused the attention of the medical world on the need for specialists in plastic surgery. In 1937, the American Board of Plastic Surgery was formed and became an affiliate of the American Board of Surgery. It was recognized as an independent Board in 1941, with the proviso that its diplomates be trained to cover a wide field of plastic surgery and that at least a two year residency in general surgery after the internship, or its equivalent, precede the two years of training in plastic surgery. Present day general surgical residencies, with rotation through the various surgical services, preliminary to taking up plastic surgery, produce men capable of performing better plastic surgery. However, surgery must pro-

vide places for such training. A man can then determine his natural bent and branch out into plastic surgery if he shows he has a flair for this specialty. An increasing number of residencies in plastic surgery are now available to hasten the acquisition of proficiency in this field, which earlier surgeons had to attain by years of "trial and error" methods.

The plastic surgeon is presented with difficult problems frequently bungled by those in other branches of surgery. It is not requisite that only a plastic surgeon repair deformities in all fields, but surgeons in all fields should be familiar with plastic surgical principles and with what can be accomplished by plastic surgery. The patient will benefit in complicated cases when the plastic surgeon's wider experience and knowledge of what can be accomplished by one of many procedures is utilized. There should be a close union between plastic surgery and the other surgical services. Operations may be performed jointly or with a plastic surgeon in full charge, and with the aid, if necessary, of specialists in the field or fields involved.

What must be sought is the best interest of the patient.

Plastic surgery frequently has to deal with many problems involving the medical as well as all the surgical specialties: metabolism, dermatology, radio-therapy, endocrinology, physical therapy, occupational therapy, pediatrics, neurology, and especially psychiatry. Practical horse-sense in sizing up a patient's mental situation is essential in determining what treatment, if any, should be advised; a schizophrenic, if operated upon, may cause endless worry to or even the death of the plastic surgeon.

Cases are shown which present problems related to a number of medical and surgical specialties; they illustrate deformities covering a wide field which were corrected by plastic surgical methods. "Plastic surgery", as John Staige Davis frequently said, "extends from the top of the head to the sole of the foot."

DISCUSSION

Dr. William P. Longmire, Jr.: Mr. Chairman, I should like to take this opportunity to express our thanks to Dr. Webster for coming here this evening. It has been instructive to see the various cases which he has presented. His discussion emphasizes the wide range of plastic surgery and the correlation of this type of surgery with the other surgical specialties. We have frequently encountered such combined problems at this hospital.

Dr. Foster and Dr. Hanrahan are to be commended for the conservative manner in which their investigation of homografts has been presented. On several occasions in the past, methods have been presented in the literature to insure the permanent survival of homografts, but all such methods have subsequently been proved erroneous.

The information presented, as Dr. Hanrahan and Dr. Foster have emphasized, concerns a single graft; however, their method of investigation is certainly an interesting one which should be explored further.

It seems that the superficial epithelium of this graft has been replaced by the

host epithelium. On the other hand, there are hair follicles and sweat glands deep within the graft which are composed of the original tissue of the donor. As far as I am aware, this is the first time that a similar demonstration has been presented, and it suggests a new avenue of investigation of the homograft problem.

Dr. Edward M. Hanrahan: There is one word I might add to what Dr. Foster has said, and which he did not have time to go into more than briefly. At first glance, it might seem as though the behavior of the pigment in this graft might give a lead as to whether or not it really is a persistence of white color or an ingrowth of colored skin. Unfortunately, pigment behavior about a graft, autograft or homograft, cannot be taken as a measure of that growth. Even the best autografts will sometimes show increase in pigmentation, sometimes show a blanching out to dead white, and a few will stay their normal color. Perhaps you have noticed in the surrounding skin of this colored patient that there was an increase in pigmentation of her own skin in addition to the ingrowth, or in addition to the appearance of pigmentation on the graft. That actually is a very old observation. It was referred to by Reverdin who tried the same thing. Loeb, in 1898, used spotted guinea-pigs. He transplanted black skin onto a white area on the same pig and reversed the process, transplanting white skin onto a black area. The black pigment of the graft would grow onto the white skin surrounding it. Where the white was put in the middle of black skin, the black pigment of the surrounding skin grew into the graft. We have seen on colored patients, where a successful full thickness graft might slough off the superficial layers, that the graft itself will turn white, but pigment returns. The reason for the behavior of these pigmentary changes has never been explained. Loeb advanced several theories. Karg found the same thing in transplants of negroes to whites and whites to negroes, and his were some of the earlier observations on what appeared to be successful homografts. It would help if the pigment would indicate whether or not the graft has persisted, or has been overgrown, but it does not.

Dr. Jerome P. Webster: May I say I think it is splendid to see the amount of interest that is being shown here in plastic surgery. I am delighted.

There was a time when Dr. John Staige Davis had as a patient on Marburg a man of great influence who promised that certain monies would come to the Johns Hopkins Hospital for a surgical clinic and that Dr. Davis would have one floor for plastic surgery cases. Unfortunately, that apportionment was never made in the Halsted Clinic. Dr. Staige Davis was never given the opportunity to develop plastic surgery as he might very well have done, making Hopkins very far ahead in the field at that time. I am delighted to see that this specialty is coming into the foreground and that there is such an interested group of men doing this work.

One should be a little careful in giving priority to anybody on any procedure. While it is excellent to bring out, as Dr. Egerton did, that Dr. Cannon was the first one to popularize that procedure, however I did it fifteen years ago, and I am sure others used the principle longer ago than that; Cannon was not in plastic

surgery at that time. There are so many things in plastic surgery, in any surgery, that have been thought of before, that one has to be very careful in saying who is the originator of a method. J. Mason Warren used a free skin graft long before Reverdin and Thiersch, who are given credit.

Certainly the microscopic section of the skin homograft, which Dr. Hanrahan showed me the latter part of November, indicates that the epithelial covering did come in from the surrounding epithelium. I would not comment regarding the persistence of the original epithelium, but, as he pointed out, certainly the epithelial elements down in the derma did persist and this would indicate that it survived. We know that certain elemental tissues such as the cornea survive as homografts, and that successful corneal transplantation can be performed. That, of course, is the one tissue that we have in the exterior of the body that persists from our fish ancestors. The cornea has to be covered with a moist covering. The tears make it able to live without drying.

About a month ago I saw a homograft in Montevideo in exactly the same position as Dr. Hanrahan's. It had been there approximately the same length of time, and no particular drugs had been given to that patient. Dr. McDonald, one of my former residents, has used more than 250 square inches of skin as a homograft on a burned patient, and this lasted more than ten weeks. I do not mean to say that the graft in this patient is going to come off, and I do not think, from the appearance that I saw in November, that it is. But the graft of the patient in Montevideo looked exactly the same as that of Dr. Hanrahan's, and no drugs had been given. You cannot draw conclusions from *one* case.

I would like to recall the reports of the former observers who said homografts of skin would take, men such as Carrel, who used baby skin and cadaver skin as homografts, and said it survived. Were these men poor observers, or did the homografts actually survive? It is difficult to say. Staige Davis maintained that he knew they survived in at least one or two cases. I wonder if our present difficulty of getting homografts to take, except in identical twins, might not be due to the fact that we are giving a great many protective injections of one thing or another nowadays, such as horse serum, and may be sensitizing ourselves in some way? I don't know. The patient I saw in Montevideo came from the interior of Uruguay where I doubt if any of those injections had been given. It is either a matter of poor observation of the homograft healing in the past, or something has changed the patient's serum so that nowadays we are not getting homograft takes. At least this sensitization is a suggestion to consider.

In regard to the cases reported by Dr. Longmire which he terms arterial hemangiomas, I have observed the same condition many times and also find it is very hard to classify these cases. There was one case I had of hemangioma of the foot, in which a definite bruit was heard in the afferent vessels and yet no definite demonstration could be made of any arterio-venous fistulae by injection of opaque fluid. There was another case with the same condition where there was no bruit, and it was treated by irradiation and the injection of sclerosing fluids.

With the ligation of all the afferent vessels and the injection of sclerosing fluid,

I believe you can get the best result with less danger in those cases where function or appearance might be impaired by operation.

In regard to Dr. Hanrahan's treatment of facial paralysis, he has done some excellent work on the improvement of that deformity. I use, as far as possible, the anterior third of the masseter as a transplant, taking also the periosteum with the muscle to use for suturing because the sutures otherwise will pull out of the muscle fibers.

At a plastic surgery meeting, I saw a surgeon take three portions of the temporal muscle, using local anesthesia, and swing the end of one to the corner of the mouth, one about the eyelids, and one to the frontal muscle. When finished operating, he said to the audience, "You know it is remarkable how fast these patients get these functions back." To the patient he said, "Will you smile?" The patient smiled. "Will you close your eye?" The patient did. "Will you raise your eyebrow?" The patient did. I leave it to you whether that was a successful result or chicanery.

BOOK REVIEWS

(These reviews represent the individual opinions of the reviewers and not necessarily those of the members of the Editorial Board of this Journal)

Clinical Examination of the Nervous System, 8th Edition. By G. H. MONRAD-KROHN. Illus. 380 pp. $4.50. *Paul B. Hoeber, Inc., New York, New York*, 1947.

This helpful little book on Neurological diagnostic methods is somewhat larger than the previous editions, but follows the same general arrangement. It continues to limit its discussion to the various diagnostic techniques, mentioning specific syndromes only as illustrating the method of examination described. This is excellent for the advanced student with some background in neurology, but is apt to be confusing to the less experienced student, unless used in conjunction with some more complete textbook. The routine methods are well described. There is also considerable discussion of spinal fluid examination, neurological radiology, and angiography.

Several striking omissions are noted. There is no discussion of electroencephalography, which is so widely used as a diagnostic method in this country. There is no mention of the neostigmine test for myasthenia gravis. The chapter on psychosomatic examination is limited to a brief discussion of aphasia. The psychiatric aspects of the examination are brief and reflect purely Kraepelinian concepts, instead of the more modern dynamic approach prevalent in this country.

Despite these limitations, this book will doubtless continue to be popular among students and physicians interested in learning the technique of neurological examination.

G. G. M.

Diabetes and the Diabetic in the Community. By MARY E. TANGNEY. Illus. 259 pp. $2.75. *W. B. Saunders Company, Philadelphia, Pennsylvania*, 1947.

While primarily written for nurses, this book will be of some value to practicing physicians as well. The routine care of diabetics is thoroughly covered in a clear, concise, easy-to-read style. The author fails, however, to stress the importance of completely drying the alcohol-sterilized insulin syringe before withdrawing protamine insulin.

The short discussions of the physiological disturbances are over simplified and at times superficial, but they serve as an adequate background for the supervision of diabetic patients. The chapter on diabetes and pregnancy treats a very controversial subject in a didactic manner. The parenteral use of massive doses of stilbestrol and progesterone to correct hormonal imbalance during pregnancy is discussed as if it were a routine form of treatment. In reality, it is still in the ex-

perimental stage and too expensive for the average patient. The author states that these hormones must be given by injection because they lose about 90% of their efficiency when given orally. This is not true of stilbestrol, which is highly effective by mouth. Lastly, the author states that diabetes does not develop in the children of diabetic mothers unless the father carries the trait. While this is true, children of diabetic mothers whose husbands do not carry the trait may transmit the disease to their children.

H. F. K., Jr.

Diagnosis in Daily Practice. By Benjamin V. White and Charles F. Geschickter. Illus. 693 pp. $15.00. *J. B. Lippincott Company, Philadelphia, Pennsylvania*, 1947.

The authors have used mortality and morbidity statistics as a basis for their selection of the more common physical and mental disease entities which should be recognized promptly by the practicing physician. Symptoms and clinical findings are then to be evaluated for indications for further diagnostic studies. The proper studies are outlined. A compendium of clinical and diagnostic data and an outline for routine physical examination are given as an aid to enable the physician to recognize and differentiate the diseases.

In a single volume an effort has been made to cover practically the entire field of medicine by means of sign and symptom outlines, abbreviated descriptions of disease complexes, diagrams, and photographs. The attempted scope of the work is of such magnitude that no single subject is in any manner adequately covered.

It is the feeling of this reviewer that good diagnosis cannot be reduced to such simple terms.

C. H. B.

Diseases of Metabolism, 2nd Ed. Edited by Garfield G. Duncan. Illus. 1045 pp. $12.00. *W. B. Saunders Company, Philadelphia, Pennsylvania*, 1947.

This volume brings together a group of surveys covering the chief fields of metabolic interest. The contributors are recognized authorities in their fields. The presentations are clear and well organized. The approach is primarily metabolic. A great deal of fundamental information is presented in detail. The vitamins and avitaminoses are described extensively. Endocrinology enters only so far as it affects metabolism. Diabetes mellitus and insipidus, hyperinsulinism, and disorders of the thyroid gland receive individual attention. The anterior pituitary, adrenals, and parathyroids are mentioned under suitable metabolic subjects. The gonads and their metabolic effects receive scant attention. Renal disease and various aberrations of metabolism are well covered.

The editor has brought together a valuable symposium on metabolism and metabolic disorders. Some overlapping and omissions are almost inevitable in a large collaborative enterprise. The description as a "text book for the practitioner" is justified by the large content of clinical interest. Although some chap-

ters might make difficult reading for the practitioner, the usefulness as a reference work would be considerable.

J. A. L., Jr.

Nursing. By Lulu K. Wolf. Illus. 534 pp. $3.50. *D. Appleton-Century Company, New York, New York,* 1947.

Miss Lulu K. Wolf addresses her book on nursing to student nurses in their first year of school. The book is divided into three parts. In Part I, the student is oriented to the profession of nursing, giving her the broad trends and philosophy which have brought nursing to the present day level of an emerging profession. She is acquainted with the nation's health problems and the part played by the nurse in the health programs.

Part II helps the student to become familiar with the hospital as one of the community's health centers. The importance of the patient's introduction to the hospital and its environment is discussed in detail.

Part III orients the student to the numerous practical procedures and principles of nursing involved in patient care. At the end, emphasis is given on the necessity of helping the patient and family plan for the patient's return and care at home.

Miss Wolf's conversational style of writing makes for a clear and personal approach to students. The frequent illustrations help to clarify the details of nursing procedure.

I feel that many instructors of nursing arts will welcome this as a text.

M. F. G.

Nursing in Modern Society. By Mary Ella Chayer. 288 pp. $4.00. *G. P. Putnam's Sons, New York, New York,* 1947.

"Nursing in Modern Society" is, as its title suggests, a thought-provoking discussion of the problems and opportunities which face the nursing profession today.

The author is a skillful teacher and presents her subject matter in a style which is clear, concise, and altogether delightful. She uses the device of giving just enough about historical events and present issues to make her point, to give the reader perspective, and to whet the appetite for more. This desire for further enlightment is strengthened by the inclusion of a comprehensive bibliography of source material.

The book is one which will appeal to all persons interested in nursing. Whether the reader is chiefly concerned with legislation, nursing education, public health trends, or how to get more adequate nursing service for the community, he will find these and many more questions offered for thought and study.

The need for a solution of present dilemmas which face the profession is discussed; and original, forward-looking plans proposed. In subject matter of this nature, controversial issues are raised, of necessity, and will arouse wholesome argument.

The message which is emphasized throughout this work is that the professional nurse needs a broader preparation for community and world service, and a new,

sharper awareness of the social forces whose impact is shaping her work. This presupposes drastic changes and a new design for nursing education curricula.

This volume is divided into three sections:

I The Impact of Social Forces Upon Nursing.

II The Influence of Social Forces Upon Community Health Needs.

III Building a Better Future.

It introduces a proposed new series of books with the general title "Modern Nursing." It is the kind of book which should be made available to all nurses in hospitals and public health agencies, and would be invaluable as a text for undergraduate and graduate class discussion groups.

G. L. C.

Surgery of the Ambulatory Patient. 2d Edition. By L. KRAEER FERGUSON. Illus. 932 pp. $10.00. *J. B. Lippincott Company, Philadelphia, Pennsylvania,* 1947.

The new second edition brings the original 1942 volume up to date. This text, since its original publication, has been extremely popular with surgeons, house officers, and students. The reason is not hard to find; the book supplies a real need in dealing constructively with what generally has been known as "minor surgery" from a new and forceful angle. Written by an author and collaborators who have had wide experience in out-patient and office work, the contents are authoritative and practical, though not encyclopedic. The material is well arranged, covering a wide field of congenital, inflammatory, and neoplastic diseases, while a generous section is devoted to the musculoskeletal system, including fractures. A helpful quick reference graphic index of the soft tissues and of the musculoskeletal system is found on the inside cover and flyleaf. There are more than 600 illustrations, many of them demonstrating technics of treatment. The volume is nicely printed on good paper. This book deserves a place in the library or on the desk of any student, surgeon or practitioner who wants an authoritative reference volume for out-patient and office surgical practice.

S. McL.

Textbook of Medicine, 7th Edition. Edited by RUSSELL L. CECIL. Illus. 1730 pp. $10.00. *W. B. Saunders Company, Philadelphia, Pennsylvania,* 1947.

The seventh edition of this outstanding text follows the general pattern of previous editions. A good deal of new material has been added, and the information and references are uniformly up to date. There are a number of welcome additions to the roster of contributors. The seventh edition is recommended as a remarkably complete and usable text for study or reference.

J. A. L., JR.

BOOKS RECEIVED FOR REVIEW

Applied Medical Bacteriology. By MAX S. MARSHALL. 340 pp. $4.50. *Lea & Febiger, Philadelphia 6, Pennsylvania,* 1947.

Brain and Intelligence. By WARD C. HALSTEAD. Illus. 206 pp. $6.00. *University of Chicago Press, Chicago, Illinois,* 1947.

Congenital Malformations of the Heart. By HELEN B. TAUSSIG. Illus. 618 pp. $10.00. *Commonwealth Fund, New York, New York,* 1947.

Contemporary American Family, The. By ERNEST R. GROVES and GLADYS HOAGLAND GROVES. 838 pp. $4.50. *J. B. Lippincott Company, Philadelphia, Pennsylvania,* 1947.

Emotional Maturity. By LEON J. SAUL. 338 pp. $5.00. *J. B. Lippincott Company, Philadelphia, Pennsylvania,* 1947.

Four Hundred Years of a Doctor's Life. By GEORGE ROSEN and BEATE CASPARI-ROSEN. 425 pp. $5.00. *Henry Schuman, New York, New York,* 1947.

Gynecological and Obstetrical Urology. By HOUSTON S. EVERETT. 2nd Edition. Illus. 539 pp. $6.00. *The Williams & Wilkins Company, Baltimore, Maryland,* 1947.

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Pharmacology and Experimental Therapeutics. By HAMILTON H. ANDERSON, FUMIKO MURAYAMA, and BENEDICT E. ABREU. 368 pp. $6.50. *University of California Press, Berkeley, California,* 1947.

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Surgical Treatment of the Abdomen. Editors: FREDERIC W. BANCROFT and

PRESTON A. WADE. Illus. 1026 pp. $18.00. *J. B. Lippincott Company, Philadelphia, Pennsylvania*, 1947.

Textbook of General Surgery. 5th Edition. By WARREN H. COLE and ROBERT ELMAN. Illus. 1160 pp. $11.00. *D. Appleton-Century Company, Inc., New York, New York*, 1947.

Textbook of Human Physiology. By WILLIAM F. HAMILTON. Illus. 503 pp. $6.00. *F. A. Davis Company, Philadelphia, Pennsylvania*, 1947.

Textbook of Pathology, A. 5th Edition. By WILLIAM BOYD. Illus. 1049 pp. $10.00. *Lea & Febiger, Philadelphia, Pennsylvania*, 1947.